Panel—Market-Based Acquisition

Wednesday, May 18, 2005 1:00 p.m. – 2:30 p.m.	**Market Based Government Cases**
	Chair: Steve Kelman, John F. Kennedy School of Government **Discussant: David Drabkin**, General Services Administration **Papers:** *"Market-based Government: The Results to Date"* Jacques S. Gansler, University of Maryland *"Developing Systems in a Changing Environment: An Army Example"* *"Public-Private Partnership Improves Aircraft Readiness"* *"Privatizing the Naval Surface Warfare Center Depot at Louisville"* William Lucyshyn, University of Maryland

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Chair: Steve Kelman—Albert J. Weatherhead III and Richard W. Weatherhead Professor of Public Management, John F. Kennedy School of Government, Harvard University. From 1993-1997, he was the Administrator of the Office of Federal Procurement Policy at the U.S. Office of Management and Budget, where he was a leading figure in reinventing government efforts. He is a Fellow of the National Academy of Public Administration and serves on the Editorial Board of the *Journal of Public Administration Research and Theory*. He is the author *of Procurement and Public Management: The Fear of Discretion and the Quality of Government Performance* and of *Making Public Policy: A Hopeful View of American Government*. His earlier books include *Regulating America, Regulating Sweden: A Comparative Study of Occupational Safety and Health Policies*; *What Price Incentives?: Economists and the Environment*; and *Push Comes to Shove: The Escalation of Student Protest*. Kelman's research on public-sector operations management focuses on organizational design and change.

Discussant: David Drabkin—the Deputy Associate Administrator for Acquisition Policy and Senior Procurement Executive, General Services Administration. He is a member of the bar of the Commonwealths of Pennsylvania and Virginia and a member of the Council of Fellows and Board of Advisors of the National Contract Management Association. David was formerly the Deputy Program Manager, Pentagon Renovation Program.

David has also served as the Assistant Deputy Under Secretary of Defense (Acquisition Process and Policies), Office of the Deputy Under Secretary of Defense (Acquisition Reform) (ODUSD(AR)) and Director, Regulatory Reform and Implementation, ODUSD(AR), where he served as the Project Manager for FASA Implementation.

David is a native of Mount Vernon, New York. He is married to the former Jane Anne Saperstein of Bridgeville, Pennsylvania. Jane and David have 2 children, Aaron and Sarah. David is a Distinguished Military Graduate of Washington and Jefferson College and a graduate of the Cumberland School of Law. He chaired NCMA's Board of Advisors for two years. He serves as Co-Chairman of the Acquisition Reform subcommittee and served as the Vice Chairman of two other committees of the American Bar Association, Government Procurement and Alternative Dispute Resolution. He also chaired an inter-agency group working under the auspices of the Administrative Conference of the United States on the implementation of Alternative Dispute Resolution within the federal government.

Since graduating from law school, David served as: Deputy District Counsel and the Associate Counsel (Contract Law), the Defense Contract Management District West (DCMDW), Defense Logistics Agency (DLA); Associate General Counsel (Procurement) and the Alternative Dispute Resolution Specialist, Office of the General Counsel, DLA; Chief Counsel, Defense Contract Management Region - New York; Chief, Administrative and Civil Law Division, Headquarters (HQ), USASETAF and 5th TAACOM, Vicenza, Italy; Administrative Law Officer, HQ, V Corps, Frankfurt, Germany; Hearing Officer, Virginia Alcoholic Beverage Control Commission, Richmond, Virginia; and, the Chief, Military Justice, USASC and Ft. Gordon, Ft. Gordon, GA.

David received numerous awards recognizing his performance. Most recently he was honored for a second time as one of the Top 100 Federal IT Executives. He was also recognized by AFFIRM's Leadership Award in Acquisition & Procurement and as one of the Top 100 Federal IT Executives in 2002. He is also the recipient of: DoD Meritorious Civilian Service Award; DoD Exceptional Civilian Service Award; Office of the Secretary of Defense Award for Excellence; Defense Logistics Agency Meritorious Civilian Service Award; Department of the Army Meritorious Civilian Service Award; Department of the Army Superior Service Award; Department of the Army Commander's Award; and, CINCUSAREUR Award. David received of the Vice President Heroes of Reinvention (Hammer) Award.

David has authored several articles and manuals on contract, international and labor law and Alternative Disputes Resolution. David also served as an adjunct faculty member at Florida Institute of Technology and a visiting lecturer at the Defense Systems Management College where he taught Contract and Intellectual Property Law.

Market-based Government: The Results to Date

Presenter: The Honorable Jacques S. Gansler, former Under Secretary of Defense for Acquisition, Technology, and Logistics, is the University of Maryland's Vice President for Research and the Roger C. Lipitz Chair in Public Policy and Private Enterprise. As the third-ranking civilian at the Pentagon from 1997 to 2001, Professor Gansler was responsible for all research and development, acquisition reform, logistics, advance technology, environmental security, defense industry, and numerous other security programs. Before joining the Clinton Administration, Dr. Gansler held a variety of positions in government and the private sector, including Deputy Assistant Secretary of Defense (Materiel Acquisition), assistant director of defense research and engineering (electronics), executive vice president at TASC, vice president of ITT, and engineering and management positions with Singer and Raytheon Corporations. Throughout his career, Dr. Gansler has written, published, and taught on subjects related to his work. He is a Member of the National Academy of Engineering and a Fellow of the National Academy of Public Administration. Additionally, he is the Glenn L. Martin Institute Fellow of Engineering at the A. James Clarke School of Engineering, an Affiliate Faculty member at the Robert H. Smith School of Business and a Senior Fellow at the James MacGregor Burns Academy of Leadership (all three at the University of Maryland). During 2003–2004, he served as Interim Dean of the School of Public Policy at that institution.

The federal government spends an incredible amount of money on the purchase of goods and services. In 2003, that spending was $230 billion, or 2% of the United States' GDP. Although it has always been the stated policy of the United States Government not to produce commercial goods or services that are available on the open market, in practice, the government often duplicates functions the private sector can provide.

The government's FY 2000 Inventory of Commercial Activities identified over 800,000 government employees who were performing commercial activities. OMB circular A-76 defines a commercial activity, "as a recurring service that could be performed by the private sector and is resourced, performed, and controlled by the agency through performance by government personnel, a contract, or a fee-for-service agreement."

To address this duplication, there is a significant change taking place in government management (federal, state, and local) from the government as the historic "provider" of public services, to the government as the "manager of the providers" of services to the public. The goal of market-based sourcing is not necessarily to move all those functions into the private sector, but to shift from an environment where government is the monopolistic provider to one that encourages competition—thereby increasing both effectiveness and efficiency.

When properly implemented, this change results in significant benefits: improved performance as well as lower costs. These benefits accrue regardless of whether the winner is the public- or private-sector supplier.

While the empirical data demonstrates the benefits of this shift, it is still not widely understood or accepted. Six concerns are generally raised:

- performance will deteriorate;
- costs will be higher;
- promised saving will not be realized over time;
- small businesses will be negatively impacted;
- large numbers of government employees will be involuntarily separated;
- and the government will lose control.

This presentation will present data to refute all six of these concerns, and will conclude with specific recommendation to increase the use of "market-based government."

Developing Systems in a Changing Environment: An Army Example

Presenter: William Lucyshyn, is the Director of Research and a Senior Research Scholar at the Center for Public Policy and Private Enterprise in the School of Public Affairs at the University of Maryland. Previously, Mr. Lucyshyn served as a program manager and the principal technical advisor to the Director, Defense Advanced Research Projects Agency (DARPA), on the identification, selection, research, development, and prototype production of advanced technology projects. Prior to this appointment, Mr. Lucyshyn completed a 25-year career in the US Air Force serving in various operations, staff, and acquisition positions. Mr. Lucyshyn received his Bachelor Degree in Engineering Science from the City University of New York and his Master's Degree in Nuclear Engineering from the Air Force Institute of Technology.

The first Gulf War revealed fundamental weaknesses in the Army's vast and complex logistics network. These flaws led to a lack of timeliness and inefficiency in delivering supplies, repair parts, and equipment to the units that needed them. Recognizing the need to adopt the best practices of private-sector supply-chain management, the Department of Defense (DoD) and Army leaders began strategic planning efforts directed toward logistics reform. Principal targets for reform were the Army's 30-year-old logistics information-management systems.

In August of 1997, the Army's Communications and Electronics Command (CECOM) at Fort Monmouth, NJ—the organization responsible for these antiquated systems—received direction, "to explore alternatives to modernize the wholesale logistics processes and associated information technology." During the following two years, a dedicated LMP team accomplished detailed analysis, planning, and coordination culminating in the award of a performance-based contract that outsourced Army logistics functions to a private firm: Computer Sciences Corporation (CSC).

The management team has faced many significant management challenges that include: intense Congressional scrutiny, strong opposition from the government employee union, the necessity of working with many different stakeholders, technical challenges, and changing requirements. LMP provides an excellent case for exploring the various issues involved with public-sector strategic-planning efforts in general, and with outsourcing and performance-based contracting in particular.

Public-Private Partnership Improves Aircraft Readiness

Presenter: **William Lucyshyn,** is the Director of Research and a Senior Research Scholar at the Center for Public Policy and Private Enterprise in the School of Public Affairs at the University of Maryland. Previously, Mr. Lucyshyn served as a program manager and the principal technical advisor to the Director, Defense Advanced Research Projects Agency (DARPA), on the identification, selection, research, development, and prototype production of advanced technology projects. Prior to this appointment, Mr. Lucyshyn completed a 25-year career in the US Air Force serving in various operations, staff, and acquisition positions. Mr. Lucyshyn received his Bachelor Degree in Engineering Science from the City University of New York and his Master's Degree in Nuclear Engineering from the Air Force Institute of Technology.

The mission of the Cherry Point Naval Air Depot is to provide maintenance, engineering and logistics support for a wide variety of Navy and Marine aircraft. One of the depot's primary tasks is the maintenance, overhaul, and testing of aircraft engines. Depot engineers and logistics personnel are also responsible for a wide range of logistics management, research, and engineering issues.

In the mid-1990s, the Navy became concerned with increasing costs of managing and distributing reparable Auxiliary Power Units (APUs), as well as with the units' decreasing reliability. After considering several concepts, the Navy began to explore an innovative approach: using a public-private partnership. In the spring of 2001, the Navy signed a contract with Honeywell Corporation (and subcontractor Caterpillar Logistics) to manage its APU inventory of more than 1,000 units, with repair work to be handled by its depot at Cherry Point, North Carolina. Caterpillar Logistics, a sub-contractor to Honeywell and a third partner in the venture, was selected to handle delivery of parts and storage of completed APUs until they were needed.

The contract was signed in June 2000, and the resultant partnership has made dramatic improvements in reliability and reduction in the Mean Number of Flight Hours between Unscheduled Removal (MFHBUR). Since the government did not maintain a good cost baseline, the program savings are more difficult to quantify.

Privatizing the Naval Surface Warfare Center Depot at Louisville

Presenter: William Lucyshyn, is the Director of Research and a Senior Research Scholar at the Center for Public Policy and Private Enterprise in the School of Public Affairs at the University of Maryland. Previously, Mr. Lucyshyn served as a program manager and the principal technical advisor to the Director, Defense Advanced Research Projects Agency (DARPA), on the identification, selection, research, development, and prototype production of advanced technology projects. Prior to this appointment, Mr. Lucyshyn completed a 25-year career in the US Air Force serving in various operations, staff, and acquisition positions. Mr. Lucyshyn received his Bachelor Degree in Engineering Science from the City University of New York and his Master's Degree in Nuclear Engineering from the Air Force Institute of Technology.

During the 1995 Base Realignment and Closure (BRAC) process, the Department of Defense (DoD) recommended that the Louisville depot be closed and its workloads transferred to several DoD facilities. The depot's principal mission was to overhaul and repair the Navy's multi-platform 5-inch gun and its Phalanx close-in antiaircraft system. The plan was to transfer the gun repair work to the Norfolk Naval Shipyard, Virginia, the Phalanx to the Naval Surface Warfare Center, Crane, Indiana, and the engineering support functions to the Naval Surface Warfare Center, Port Hueneme, California.

During the BRAC review process, the city of Louisville proposed to the Commission that the DoD privatize the depot workload in-place. The Commission found that the Navy's cost savings from the closure were overstated, that the gun systems engineering functions at Louisville are consistent with operational requirements, and that the maintenance and overhaul functions performed at the facility have contributed substantially to the effectiveness of the Department of the Navy.

As a result of the Commission's findings, the Navy decided to privatize-in-place the Louisville depot's operations, with some Navy program-management positions remaining at the privatized facility. The field-engineering support function would also be retained as a detachment at the privatized Louisville depot.

In July 1996, the Navy awarded contracts to two private corporations to work in conjunction with the depot: Hughes (now Raytheon) for the Phalanx system and United Defense for the gun-repair workload. Both contractors have made significant gains in productivity while bringing in additional work to the depot. This case will examine the results of this reconfiguration, nine years after the privatization.

Panel—Issues in Program Management

Wednesday, May 18, 2005	**Organizational and Business Process Reengineering Issues**
1:00 p.m. – 2:30 p.m.	**Chair:** Mark Nissen, Naval Postgraduate School **Papers:** *“An Extension and Test of the Communication-Flow Optimization Model”* Ned F. Kock, Texas A&M International University *“Determining the Best Loci of Knowledge, Responsibilities and Decision Rights in Major Acquisition Organizations”* John Dillard, Naval Postgraduate School Mark Nissen, Naval Postgraduate School *“From Market to Clan: How Organizational Control Affects Trust in Defense Acquisition"* Roxanne Zolin, Naval Postgraduate School John Dillard, Naval Postgraduate School

Chair: Mark Nissen—Associate Professor of Information Systems and Management at the Naval Postgraduate School. His research focuses on knowledge dynamics. He views work, technology and organizations as an integrated design problem and has concentrated recently on the phenomenology of knowledge flows. Mark’s publications span information systems, project management, organization studies, knowledge management and related fields. In 2000, he received the Menneken Faculty Award for Excellence in Scientific Research, the top research award available to faculty at the Naval Postgraduate School. In 2001, he received a prestigious Young Investigator Grant Award from the Office of Naval Research for work on knowledge-flow theory. In 2002, he spent his sabbatical year at Stanford integrating knowledge-flow theory into agent-based tools for computational modeling. Before his information systems doctoral work at the University of Southern California, he acquired over a dozen years' management experience in the aerospace and electronics industries.

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An Extension and Test of the Communication-Flow Optimization Model

Presenter: **Ned Kock,** is Associate Professor and Chair of the Department of MIS and Decision Science at Texas A&M International University. The National Science Foundation and the Department of Defense (the latter through its External Acquisition Research Program) have funded his research. He holds degrees in electronics engineering (BEE), computer science (MSc), and management information systems (PhD). Ned has authored several books and published in a number of journals including: *Communications of the ACM*, *Decision Support Systems*, *IEEE Transactions on Education*, *IEEE Transactions on Engineering Management*, *IEEE Transactions on Professional Communication*, *Information & Management*, *Information Systems Journal*, *Information Technology & People*, *Journal of Organizational Computing and Electronic Commerce*, *Journal of Systems and Information Technology*, *MIS Quarterly*, and *Organization Science*. He is the Editor-in-Chief of the *International Journal of e-Collaboration*, Associate Editor of the *Journal of Systems and Information Technology*, and Associate Editor for Information Systems of the journal *IEEE Transactions on Professional Communication*. His research interests include action research, ethical and legal issues in technology research and management, e-collaboration, and business process improvement.

ABSTRACT

This paper reports on a quasi-experimental action research study aimed at extending and testing the communication-flow optimization model, which was developed as a result of a prior grant from the DoD's External Acquisition Research Program. The test is aimed at demonstrating the generality of the model, which is argued to apply to non-defense as well as defense-related organizations. In the study, business process redesign groups in four different US organizations (not defense-related) used two different types of business process representation. The study suggests that, contrary to assumptions likely underlying most of the current business process redesign practice, communication flow-oriented representations of business processes are perceived by those involved in their redesign as significantly more accurate, more useful in the identification of opportunities for process improvement, more useful in the application of process redesign guidelines, more useful in the visualization of process changes, and more useful in the development of generic IT solutions to implement new business processes, than activity flow-oriented representations. The results are consistent with those obtained in similar empirical studies of business process redesign projects involving DoD branches and contractors.

KEYWORDS: Quasi-experimental Action Research, Data Triangulation, Contrast Analysis, Nonparametric Techniques, Process Redesign, Organizational Communication, Electronic Communication

INTRODUCTION

Business process redesign (or, simply, process redesign) approaches have become very popular in organizational circles, particularly since the emergence of the business process reengineering movement in the early 1990s (Hammer, 1996; Hunt, 1996; Reijers et al., 2003). The key assumption underlying the development and use of process redesign approaches is that processes can be understood and modified in such a way as to increase both their efficiency and the quality of their outcomes. In such approaches, processes are seen as the basic units of value-added work in organizations.

In spite of being touted as a new and revolutionary idea, it can be argued that process redesign has a long history, dating back to Taylor's (1911) scientific management movement. The scientific management method was concerned primarily with the improvement of manufacturing processes. It provided an approach through which managers could redesign processes in order to minimize times and motions in them, and subsequently encourage workers to follow the new process designs by means of financial incentives. The approach has worked particularly well in processes that involved the handling of heavy materials, and whose executors were largely uneducated and unskilled workers. In that context, the value of Taylor's (1911) scientific management method is undeniable, making it one of the most enduring and successful organizational development methods ever devised.

The time gap between the emergence of the scientific management method and the emergence of the business process reengineering movement is almost 100 years, and many new organizational development approaches have emerged in the interval. Notably, there was the humanist movement, which shifted the focus of organizational development from "processes" to "people," pioneered by Elton Mayo in the early and mid-1900s (Mayo, 1945), and extended by others such as McGregor, Maslow, and Herzberg (Clutterbuck & Crainer, 1990; Herzberg et al., 1959; Maslow, 1954). There was also the total quality management movement, which reverted to a focus on processes but with an emphasis on process quality rather than productivity, pioneered by Deming, Ishikawa, and Juran (Bergner, 1991; Deming, 1986; Ishikawa, 1986; Juran, 1989; Chapman, 1991; Walton, 1989; 1991).

In spite of the time gap mentioned above, many have argued that reengineering is, in fact, a modernized version of the scientific management method (Earl, 1994; Waring, 1991). When one looks at the original reengineering ideas, and the process redesign approaches that followed, it seems that this argument is generally correct. This seems to be true particularly in connection with operational versions of process redesign (Hammer & Stanton, 1995; Hunt, 1996), which, unlike their more strategic counterparts (Caron et al., 1994; Clemons et al., 1995), place singular emphasis on the modeling and redesign of the inner workings of relatively narrow processes spanning one or few areas of an organization.

Perhaps the similarity between today's process redesign practices and those propounded by the scientific management method has extended to one aspect that, this paper argues, has negative implications for the contemporary practice of process redesign. That aspect is the focus of much of today's process redesign approaches on what seems to be a focus on times-and-motions elements associated with workflows, which is reflected in an emphasis on modeling and understanding processes primarily as chronological sequences of interrelated activities (Kock & McQueen, 1996). It is argued in this paper that such focus, although appropriate for materials-handling processes, is problematic when the targets of process redesign efforts are information-intensive processes. It is also argued in this paper that most processes found in organizations today are information-intensive, and that there is a trend toward information-intensive processes significantly outnumbering materials-handling processes in organizations in general—a trend that is likely to grow in the future.

The main goal of this paper is to compare a communication flow-oriented approach to process redesign (which is arguably well aligned with the information-intensive nature of most modern processes) with an activity flow-oriented approach which reflects much of the current practice in connection with business-process redesign. The comparison is guided by a set of hypotheses which builds on a modern theoretical model of business process redesign, namely the communication-flow optimization model (Kock, 2003; Kock & Murphy, 2001). Based on that comparison, this paper argues that there must be a shift in the emphasis of current process redesign efforts, from an emphasis on activity flows to an emphasis on the webs of communication interactions that compose most of today's information-intensive processes.

The above shift is particularly important in the redesign of defense acquisition processes. Among the key reasons for this are the large sums involved in defense acquisition, and the knowledge- and information-intensive nature of those processes. In the case of the US Department of Defense and its contractors, the most widely adopted methodology for process redesign is still an activity flow-oriented methodology called IDEF0 (Ang & Gay, 1993; Dean et al., 1995; Kock & Murphy, 2001).

RESEARCH BACKGROUND

Business process redesign has been a fertile area of research, particularly in the last 10 years. Many important research issues have been addressed, and many relevant research questions have been successfully answered. Harmful misconceptions regarding process redesign have been exposed (Davenport & Stoddard, 1994), and the role of information technology as an enabler of new redesigned processes has been identified and explained (Venkatraman, 1994). Key preconditions of process redesign success have been identified (Bashein & Markus, 1994; Clemons et al., 1995; Teng et al., 1998), and related change management techniques have been studied and validated (Kettinger & Grover, 1995; Stoddard & Jarvenpaa, 1995). New methods and automated tools for process redesign have been proposed (Kock, 1999; Nissen, 1998), and successful approaches for implementation of new process designs have been identified (Grover et al., 1995).

In spite of the progress above, some areas of research in connection with process redesign have received relatively little attention. One such area is that of process representation approaches and their impact on process redesign projects (Katzenstein & Lerch, 2000). This area arguably needs its share of research attention since the way processes are looked at is likely to strongly influence the way they are redesigned. This, in turn, should significantly influence the success of process redesign (Biggs, 2000; Hammer & Champy, 1993; Katzenstein & Lerch, 2000). For example, if a contract-preparation process (arguably an information-intensive process) is represented primarily as a web of communication interactions, it is more likely that problems in connection with communication inefficiencies will be identified (e.g., unnecessary forms that are being filled out and exchanged, which may be contributing to a process bottleneck) than if the process is represented primarily as a chronological sequence of activities. While a focus on activity flows is likely to lead to changes in how activities are conducted, particularly in the sequencing of activities (which is an important consideration in materials handling and assembly line processes), a focus on communication interactions is likely to lead to changes in how information flows within a process (Davenport, 1993; Kock, 1999).

A focus on activity flows makes particularly good sense when the processes being redesigned involve the handling of tangible items (such as raw materials and machine parts) and when tangible items substantially outnumber communication interactions in the processes (Kock, 2003). The problem is that, today, very few processes fit that description. The vast majority of processes, even in manufacturing organizations, have substantially more communication interactions than materials flow interactions (Kock & McQueen, 1996). Also, in certain types of non-manufacturing processes, such as processes whose final outcomes are services or information products, it has been shown that an activity-flow focus leads to overly complex and convoluted process representations, and to several related problems in connection with process redesign (Kock, 1999).

In spite of the above, and perhaps due to the fact that most wealth creation in the last 100 years has relied heavily on manufacturing processes, most existing process redesign approaches focus on activity flows, and largely ignore the webs of communication interactions that make up a large component of modern processes (Archer & Bowker, 1995; Kock & McQueen, 1996; Kock, 2003). For example, the US Department of Defense and its contractors, which, combined, possibly form the largest group of employers in the US, have adopted an activity flow-oriented methodology called IDEF0 as their official methodology for process redesign (Ang & Gay, 1993; Dean et al., 1995; Kock & Murphy, 2001).

One widely used approach to process redesign has been proposed by Harrington (1991; see also Harrington et al., 1998), which not only takes a strong activity-flow orientation but also goes as far as stating that: "As a rule [communication flow diagrams] are of more interest to computer programmers and automated systems analysts than to managers and employees charting business activities" (p. 108). This opinion is obviously at odds with the information-intensive orientation that processes have taken since the late 1970s (Galbraith, 1977), and which has arguably reached high levels since the advent of the Internet in the late 1980s and early 1990s (Kock, 1999). Yet, interestingly, Harrington's (1991) assertion is well aligned with reengineering pioneers Hammer and Champy's (1993) view of process redesign, which permeates much of today's practice in organizational settings.

What about systems analysis and design methods? Are not they information-flow oriented? Yes, they are, but those methods (see, e.g., Davis, 1983; Dennis & Wixom, 2000) have traditionally been designed for process modeling and automation, and have rarely been successfully used as a basis for process redesign efforts (Harrington, 1991; Harrington et al., 1998; Kock & McQueen, 1996). There are some reasons for that. For example, systems analysis and design rules for the generation of business process models using data flow diagrams prevent the representation of certain inefficiencies associated with the flow of information in processes, such as a communication interaction between, say, a forklift operator and an inventory manager (represented as "terminators" in the diagrams) that does not use a data repository (e.g., an inbox) to intermediate the interaction. More generally, no two terminators can be represented as communicating with each other without a data repository intermediating the interaction in data flow diagrams (Dennis & Wixom, 2000). The reason why those rules are followed is that they are consistent with the notion, subscribed to by most systems analysis and design practitioners, that the main goal of systems analysis and design is to understand and subsequently automate business processes with the help of information technologies. Although some progress has been made in recent years, as systems analysis and design methodologists incorporate a process-redesign orientation into their approaches, such process redesign-unfriendly rules exist in both structured systems analysis and design methods, as well as in the more recently devised object-oriented systems analysis and design methods (Booch et al., 1998). In contrast with systems analysis and design, the focus of process redesign has traditionally been to understand and change (sometimes significantly) organizational processes, and then implement the new process designs through the use of information technologies (Davenport, 1993; Davenport, 2000; Hammer, 2000; Hammer & Stanton, 1997).

The picture painted above can be summarized as follows. While activity-flow approaches to business process redesign have been by far the most widely adopted, they do not seem to match the information-intensive nature of modern business processes. There have been attempts to understand that picture from a theoretical perspective, and to propose solutions to the many problems associated with it (Keen, 1997; Kock, 2003; Kock & Murphy, 2001; Ould, 1995). One such attempt led to the development of the communication-flow optimization model

(Kock, 2003; Kock & Murphy, 2001). The model, which serves as the theoretical anchor of this paper, is summarized in the next section.

THE COMMUNICATION-FLOW OPTIMIZATION MODEL

The communication-flow optimization model (Kock, 2003; Kock & Murphy, 2001) is concerned with how process redesign practitioners look at organizational processes, and how that perspective affects the efficiency and success of process redesign projects. The model was initially developed based on actual process redesign projects conducted over a period of six years (Kock, 2002), and was later validated through several projects conducted with defense contractors (Kock, 2003). The study described here is one further test of the model, and should be seen as an incremental contribution to the refinement of the model.

Several different lenses can be used to look at and understand organizational processes. Notably, processes can be looked at as sequences of interrelated activities, or as webs of communication interactions (Kock, 1999). One of the core arguments of the communication-flow optimization model is that the webs of communication interactions in a process determine, in a particularly strong way, the quality and productivity of a process. The model argues that much of the variation in the quality and productivity of processes can be explained by the communication-flow structure of those processes, and that a relatively small amount of that variation can be explained through other types of configurations, including activity-flow configurations of the process.

Another key argument made by the communication-flow optimization model, which may seem paradoxical given the above discussion, has been proposed to explain a finding that emerged from the original studies that led to the model. That finding was that, unlike members of traditional systems analysis and design projects (Davis, 1983; Dennis & Wixom, 2000), process redesign project members rarely favored the use of communication-flow representations of processes over activity-flow representations early on in their projects. Moreover, those members consistently perceived communication-flow representations of processes to be more difficult to generate and “less natural” representations of processes than activity-flow representations. The key argument put forth to explain those findings was that activity-flow representations are better aligned with the way in which the human brain has been designed to envision action than communication-flow representations (Kock, 2003). According to the model, the latter representations (communication-flow representations) are subconsciously seen as substantially more abstract, complex, and unnatural than the former.

Nevertheless, since the communication-flow structure of processes is likely to account for a substantial amount of variation in the processes’ quality and productivity, the communication-flow optimization model predicts that process redesign team members will favor communication-flow representations at the redesign stage of their projects. That is, the model predicts that process redesign team members will favor activity-flow representations early on in their projects, when the goal is primarily to analyze the process or processes that are being targeted for redesign. Later, at the redesign stage, though, when process redesign team members try to modify a process or processes with the goal of improving their quality and productivity, the model predicts that those team members will favor communication-flow representations, if any are available. Of course, in many cases those communication-flow representations will not be available, because the initial emphasis would likely have been on activity-flow representations.

Let us assume that a manager of a health insurance underwriting department is asked to come up with a diagrammatic representation of the work performed by the department, which, given the nature of those types of processes, can safely be assumed to be substantially information-intensive. According to the communication-flow optimization model, the manager would most likely draw the different activities conducted by the department, and then connect those activities in a diagram in such a way as to indicate their chronological sequence of execution. While variations could occur, rarely, the model argues, would the manager build the diagram around the communication interactions (e.g., the flow of forms, memos etc.) involved in the underwriting of health insurance. There reason for that, according to the communication-flow optimization model, is that the manager would subconsciously think of activity-flow representations of processes as more natural than communication-flow representations.

In the example above, let us now assume that the manager was asked to propose modifications in the work performed by the health insurance underwriting department, and that he was presented with two different process representations of that work—one depicting the process as a sequence of interrelated activities, and the other as a web of communication interactions. In this instance, the communication-flow optimization model argues that the manager would favor the latter representation in his or her redesign of the process. The reason for that, according to the model, is that most process-related inefficiencies are likely to be caused by underlying communication-flow problems. Moreover, in the implementation of the redesigned process using IT, the model argues that communication-flow representations provide a better visualization tool than activity-flow representations, since there is a clear correspondence between the key elements of communication-flow representations (e.g., data stores) and the key elements of the IT systems used to implement new processes (e.g., databases).

As far as process redesign projects are concerned, the communication-flow optimization model argues that most people will tend to put emphasis on activity flows early on in their process redesign projects, and keep that emphasis throughout their projects, especially if they do not follow a process redesign methodology that somehow “forces” a focus on communication flows. This, in turn, will more often than not lead to sub-optimal process redesign results. That is, the model argues that a somewhat forced focus on communication flows will likely lead to better process redesign results than a natural focus on activity flows.

It is important to note that the communication-flow optimization model is a relatively narrow type of theoretical model, particularly regarding two main aspects. First, the model is concerned with operational-level process redesign projects, which differ substantially from strategic-level projects. In operational-level process redesign projects (see, e.g., Harrington et al., 1998), the main focus is the quality and/or productivity improvement of local processes, which are usually housed in one single department or cut across a few related departments or areas (e.g., warehousing and distribution). Projects involving strategic-level process redesign (see, e.g., Hammer & Champy, 1993), on the other hand, are usually aimed at reengineering broad processes, often processes that cut across an entire company. Second, the model is concerned with process redesign projects in which human beings produce representations of the processes and, based on those representations, come up with new process designs. That is, the model does not address nor dismiss the usefulness of process redesign techniques based on operations research, linear programming, and other traditional assembly-line and factory design techniques that can often be largely automated and that rely to a very little extent on subjective human judgment.

HYPOTHESES

This action research study tested a set of hypotheses derived from the communication-flow optimization model within the context provided by four group-based process redesign projects facilitated in four different organizations. The researcher provided methodological facilitation to the groups. To foster a multiple-perspective view of the target processes, as well as to avoid facilitation-induced bias, the researcher encouraged process-redesign groups to generate both activity-flow as well as communication-flow representations of their target processes, and to consider both types of representations when redesigning the target processes.

The communication-flow optimization model argues that one of the key reasons why individuals prefer activity-flow representations of processes is because those types of representations are better aligned with the way human beings envision "action." As such, it is reasonable to expect activity-flow representations to be seen, when compared with communication-flow representations, as easier to generate and understand, as well as more accurate and complete representations of processes. These predictions are embodied in hypotheses **H1** to **H4** below.

> ***H1:*** *Process redesign group members will perceive communication-flow representations of business processes as more difficult to generate than activity-flow representations.*
>
> ***H2:*** *Process redesign group members will perceive communication-flow representations of business processes as more difficult to understand than activity-flow representations.*
>
> ***H3****: Process redesign group members will perceive communication-flow representations of business processes as less accurate than activity-flow representations.*
>
> ***H4****: Process redesign group members will perceive communication-flow representations of business processes as less complete than activity-flow representations.*

It is important to test hypotheses **H1** to **H4** to assess the communication-flow optimization model's claim (Kock & Murphy, 2001) that process redesign group members rarely think of processes in terms of communication interactions at the outset of their process redesign efforts, rather thinking of processes in terms of chronological sequences of interrelated activities, or activity flows, because the latter are better cognitively aligned with the way human beings think of "action." This claim provides an explanation for what seems to be a generalized preference for activity flow-based process-redesign approaches today (Katzenstein & Lerch, 2000; Kock, 1999) and is, thus, central to the communication-flow optimization model.

Nevertheless, the model also predicts that a communication-flow focus is generally more effective than an activity-flow focus in the context of process redesign projects. In this study, where both communication- and activity-flow representations are used, this would arguably translate into a "change of mind" after the beginning of a process redesign project, reflected in favorable perceptions toward, as well as preferences for, communication-flow representations, as the project moves from process analysis to process redesign. According to the model, this should be particularly noticeable in the redesign phase, where process redesign group members propose changes to a process they already selected and analyzed in some detail. Underlying this predicted preference for communication-flow representations is the heavy role that information technologies are likely to play on process redesign implementations, and the consequent need to address the flow of communication in the processes targeted for redesign (Kock, 1999). This leads us to hypotheses **H5** to **H8** below.

> ***H5**: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the identification of opportunities for improvement than activity-flow representations.*
>
> ***H6**: Process redesign group members will perceive communication-flow representations of business processes as more useful in the application of process redesign guidelines than activity-flow representations.*
>
> ***H7**: Process redesign group members will perceive communication-flow representations of business processes as more useful in the visualization of process changes than activity-flow representations.*
>
> ***H8**: Process redesign group members will perceive communication-flow representations of business processes as more useful in the development of generic information technology solutions than activity-flow representations.*

Hypotheses **H5** to **H8** assume that, when employing communication-flow and activity-flow representations during a process-redesign project, the perception of process redesign group members about each type of representation will reflect a rational intention to achieve the best results possible. This can be seen as a reasonable assumption in connection with the group-based projects investigated here because those were real (as opposed to simulated) projects involving individuals who knew they were responsible for the outcomes of their projects, whether those outcomes were "good" or "bad."

RESEARCH METHOD

Action research: The roots of organizational action research are in studies of social and work life issues (Fox, 1990; Lewin, 1946; Trist et al., 1970). Organizational action research is often uniquely identified by its dual goal of both improving the organization (or organizations) participating in the research study, and at the same time generating knowledge (Elden & Chisholm, 1993; Lau, 1997). A growing body of literature exists on the use of action research in organizational studies in general, as well as in the more specific context of information systems research (Avison et al., 1999; Baskerville, 1997; 1999; Baskerville & Wood-Harper, 1996; 1998; Myers, 1997; Olesen & Myers, 1999), where research on process redesign has flourished since the early 1990s. Due to space limitations, this literature is not reviewed here. The reader is referred to Lau (1997) for a seminal review of action research within the field of information systems research. Peters and Robinson (1984), as well as Elden and Chisholm (1993), provide more general and discipline-independent reviews of action research. For the purposes of this investigation, it suffices to highlight the fact that, in organizational-action research, the action researcher is expected to apply positive intervention on the organization (Jonsonn, 1991), which is often realized by the researcher providing some form of service to the organization and its members.

By providing a service to a client organization, the action researcher aims to foster a sense of collaboration with his or her subjects, which characterizes most action research projects. This sense of collaboration is believed to promote free information exchange and a general commitment, from the researcher as well as the subjects, toward both research quality and organizational development (Argyris & Schon, 1991; Avison et al., 1999; Fox, 1990). One of the key reasons for the emergence and relative success of action research has been the recognition that the behavior of an organization, group, or individual, can be more deeply understood if the researcher collaborates with the subject or subjects being studied. In the case of an organization, this can be achieved when the researcher facilitates improvement-oriented change in the organization, which was the case in the investigation described in this paper.

QUASI-EXPERIMENTAL ACTION RESEARCH

More often than not, action research is used as an approach to collect and analyze qualitative data. Nevertheless, one of action research's pioneers, namely Kurt Lewin, set a precedent for the use of action research in predominantly quantitative studies, in what later became known as the "classical" variety of action research (Elden & Chisholm, 1993). Lewin often saw action research studies as quasi-experiments, with one key characteristic that set those studies apart from traditional field experiments. That characteristic is that the intervention applied by the researcher is aimed at solving a practical problem, rather than generating an experimental control group. This perspective is adopted here, where action research is employed in a quasi-experimental fashion.

The researcher provided process redesign training and facilitation to the members of four process redesign groups involving consultants, employees and management from four different organizations based in the US. The facilitation was solely methodological (e.g., no specific process redesign suggestions were offered), and also "methodologically neutral" so as not to bias the perceptions of the subjects about the redesign approaches used. The process redesign groups conducted their work independently from each other.

THE GROUPS STUDIED AND THEIR STAGES

The research literature suggests successful process-redesign projects are usually conducted by cross-departmental groups that are typically small in size (usually less than 15 members) and that have a short lifetime (from a few days to typically no more than a few months) during which its members define, analyze, and search for alternatives to improve one or a few organizational processes (Caron et al., 1994; Choi, 1995; Choi & Liker, 1995; Hammer & Stanton, 1995). The process-redesign groups studied here presented these same general characteristics. They lasted approximately 3 months each, had a "core" membership of 3 to 5 members (assigned nearly full-time to the process-redesign projects), and had a "peripheral" membership of 5 to 10 members (which involved external advisors, consultants, and administrative support personnel assigned on a part-time basis to the process-redesign projects). All of the groups were cross-departmental (i.e., they involved members from more than one department) and targeted cross-departmental processes (i.e., processes that involved more than one department in their execution). The term "departments" is used here to refer to organizational units that aggregate employees with expertise in related organizational functions, e.g., marketing department, computer support department, and quality control department.

According to the research and business literature, process-redesign groups usually conduct their activities along three main conceptual stages: *definition*, *analysis*, and *redesign* (Davenport, 1993; Davenport & Short, 1990; Dennis et al., 1999; Hammer & Champy, 1993; Hammer & Stanton, 1997; Harrington, 1991; Harrington et al., 1998; Kock, 2001). In the definition stage, the process-redesign group selects a process for redesign. In the analysis stage, the group studies the process in detail. Finally, in the redesign stage, the group proposes process-design modifications. These stages are followed by the implementation of the modifications. The process-redesign groups studied followed this general structure.

In the analysis stage, each process-redesign group developed both activity-flow and communication-flow representations of their target processes. Activity-flow representations followed the general format proposed by Harrington et al. (1998) for functional timeline flowcharts. While both types of representations contained different types of information, they generally embodied the same “amount” of information (i.e., neither was substantially more “information-rich” than the other). Communication-flow representations were adaptations of data-flow diagrams (Davis, 1983; Dennis & Wixom, 2000), and were generated following the modified format proposed by the researcher (Kock, 1999).

In the redesign stage, each process-redesign group independently proposed several major process changes. Those changes were proposed without interference from the researcher. A list of generic process-redesign guidelines, previously compiled by the researcher (Kock, 1999) based on a survey of the literature on process redesign, were provided to the groups to guide their work. To avoid biasing group-member perceptions in favor of activity- or communication-flow representations, the guidelines were chosen so that: (a) three of the guidelines were more meaningful in the context of activity-flow than communication-flow representations; (b) three of the guidelines were more meaningful in the context of communication-flow than activity-flow representations, and (c) two of the guidelines could be can be applied in both contexts.

Both activity-flow and communication-flow representations of the new processes, with major changes incorporated into them, were then generated. Following this, each process-redesign group developed a “generic” information technology “solution” to implement the new process. These generic information-technology solutions were essentially product-independent computer-based infrastructure and system specifications, and were illustrated through rich pictorial representations (Checkland, 1981; Checkland & Scholes, 1990; Kock, 1999; Kock & Murphy, 2001). The pictorial representations contained icons representing computers, databases and organizational functions responsible for executing individual activities of the new process.

The above stages were followed by the implementation of the recommended process changes, in most cases leading to changes in process-related procedures, reallocation of human and material resources, and use of new information-technology solutions. Implementations took from four months to eight months. Process performance reviews were conducted approximately six months after the implementation of those changes. Those reviews were based primarily on unstructured interviews with managers and employees and aimed at assessing the bottom-line business impact of the process-redesign projects. All four process-redesign groups studied were generally successful in their projects, as the process changes recommended by them met the following success criteria—they were implemented fully or partially and led to positive observable results. These success criteria are consistent with those proposed in the process-redesign literature (Burke & Peppard, 1995; Davenport, 1993; Hammer & Champy, 1993).

DATA COLLECTION AND ANALYSIS

Three main types of research data were collected and compiled in connection with the process-redesign groups: survey-instrument answers (Drew & Hardman, 1985; Sekaran, 1984), participant observation notes (Creswell, 1994; 1998; Sommer & Sommer, 1991), and unstructured interview notes (Patton, 1980; 1987). *Survey-instrument answers* were obtained through a survey administered to the “core” members of each process-redesign group (3 to 5 members) at the end of the work of each process-redesign group. In total, 17 sets of answers were obtained based on a questionnaire. *Participant observation notes* were generated based on direct observation of process-redesign group members as well as other employees who were not directly involved in process-redesign groups yet observed or were affected by the work of the groups. *Unstructured interview notes* were obtained through interviews conducted with the “core” members of each process-redesign group, as well as with other employees who were not directly involved in process-redesign groups, yet interacted with group members or were directly affected by the work of the groups. Over forty unstructured interviews were conducted in total.

The data analysis in connection with the hypotheses was focused on the search for “patterns.” The identification of patterns in the survey-instrument answers, which were obtained on a Likert-type scale, was conducted using paired-samples *t* tests (Green et al., 1997; Rosenthal & Rosnow, 1991) comparing the means for answers in connection with communication-flow and activity-flow representations. Patterns in participant observation and unstructured interview notes were identified either based on the observation that they occurred in the majority of the cases (Kock et al., 1997; Miles & Huberman, 1994), or, when the sample size for the unit of analysis under consideration permitted, based on the result of a Chi-square goodness-of-fit test comparing the observed distribution with the expected (or chance) distribution (Siegel & Castellan, 1998).

In order to increase the robustness of the data analysis, the three sources of research data—survey-instrument answers, participant observation notes, and unstructured interview notes—were extensively triangulated (Jick, 1979; Maxwell, 1996; Yin, 1994). As recommended by Maxwell (1996) and Sommer and Sommer (1991), the data set was thoroughly examined for patterns of evidence in support of and against each of the hypotheses, and all the evidence obtained was carefully summarized, compared and double-checked for inconsistencies.

RESULTS

As previously mentioned, unstructured interviews with managers and employees suggested that all of the four process-redesign groups studied were generally successful in their projects. The process changes recommended by them were implemented fully or partially and led to positive observable results, thus meeting general success criteria proposed in the process redesign literature (Burke & Peppard, 1995; Davenport, 1993; Hammer & Champy, 1993).

In this section, hypotheses-relevant results are grouped in three main categories, namely *survey-instrument answers*, *participant observation notes*, and *unstructured interview notes*. Later in the section, the several hypotheses-relevant results, both in support of and against the hypotheses, are summarized in a single table and compared against each other.

SURVEY-INSTRUMENT ANSWERS

Table 1 summarizes the results of a paired-samples *t* test applied on the survey instrument answers. In it, the “core” members of each process-redesign group (3 to 5 members) answered several questions on a Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The leftmost column of Table 1 lists 8 constructs associated with business-process representations: *ease of generation* (EASYGEN), *ease of understanding* (EASYUND), *accuracy* (ACCUR), *completeness* (COMPLET), *usefulness in the identification of opportunities* *for improvement* (OPPORTU), *usefulness in the application of process redesign guidelines* (APLLIC), *usefulness in the visualization of process changes* (VISUAL), and *usefulness in the development of generic IT solutions* (ITSOLUT). The measures for these constructs (one indicator per construct) reflect the constructs identified by Kock (1999) and Kock and Murphy (2001) based on grounded-theory research investigations (Glaser & Strauss, 1967; Strauss & Corbin, 1990; 1998).

	Mean - C	Std. deviation	Mean - A	Std. deviation	*t*	*p* (2-tailed)
EASYGEN	2.82	1.29	3.06	1.30	-0.61	0.55
EASYUND	4.18	1.07	3.82	0.81	0.92	0.37
ACCUR	4.18	0.88	3.12	1.50	2.20	< .05
COMPLET	3.35	1.37	2.59	1.23	2.02	0.06
OPPORTU	4.59	0.51	3.76	1.25	2.38	< .05
APPLIC	4.71	0.47	3.82	1.13	2.76	< .05
VISUAL	4.65	0.49	3.47	1.18	3.64	< .01
ITSOLUT	4.24	1.20	3.06	1.30	3.05	< .01

Table 1. Descriptive Statistics and Paired-samples *t* Test Results

(Quantitative data obtained from structured interview transcripts; range: 1 – 5;
Means: C = communication flow; A = activity flow)

Column "Mean – C" in Table 1 shows the means for answers referring to communication-flow representations; column "Mean – A" refers to activity-flow representations. On the right-hand sides of each of these columns are columns showing the standard deviations for each measure. The column "*t*" shows the *t* statistic for each pair of measures. Finally, the column "*p* (2-tailed)" shows the significance level for each *t* statistic based on a 2-tailed test.

The patterns of evidence listed below have been derived from Table 1. They are referred to by "SIA" (survey instrument answers) codes that are later used for data triangulation. The patterns of evidence SIA.$H1_0$, SIA.$H2_0$, SIA.$H3_0$ and SIA.$H4_0$ do not support hypotheses H1, H2, H3 and H4; that is, they provide support for the null hypotheses $H1_0$, $H2_0$, $H3_0$ and $H4_0$, respectively. The patterns of evidence SIA.H5, SIA.H6, SIA.H7 and SIA.H8 provide support for the hypotheses H5, H6, H7 and H8, respectively.

SIA.H1$_0$. On average, group members perceived communication-flow representations as more difficult to generate than activity-flow representations (see EASYGEN row in Table 1). The results of the paired samples *t* test ($t(15)=-.61$, $p=.55$) comparing perceptions for each representation were not statistically significant.

SIA.H2$_0$. On average, group members perceived communication-flow representations as easier to understand than activity-flow representations (see EASYUND row in Table 1). The results of the paired samples *t* test ($t(15)=-.92$, $p=.37$) comparing perceptions for each representation were not statistically significant.

SIA.H3$_0$. On average, group members perceived communication-flow representations as more accurate than activity-flow representations (see ACCUR row in Table 1). The results of the paired samples *t* test ($t(15)=2.2$, $p<.05$) comparing perceptions for each representation were statistically significant.

SIA.H4$_0$. On average, group members perceived communication-flow representations as more complete than activity-flow representations (see COMPLET row in Table 1). The results of the paired samples *t* test ($t(15)=2.02$, $p=.06$) comparing perceptions for each representation were not statistically significant.

SIA.H5. On average, group members perceived communication-flow representations as more useful in the identification of opportunities for improvement than activity-flow representations (see OPPORTU row in Table 1). The results of the paired samples *t* test ($t(15)=2.38$, $p<.05$) comparing perceptions for each representation were statistically significant.

SIA.H6. On average, group members perceived communication-flow representations as more useful in the application of process redesign guidelines than activity-flow representations (see APLLIC row in Table 1). The results of the paired samples *t* test ($t(15)=2.76$, $p<.05$) comparing perceptions for each representation were statistically significant.

SIA.H7. On average, group members perceived communication-flow representations as more useful in the in the visualization of process changes than activity-flow representations (see VISUAL row in Table 1). The results of the paired samples *t* test ($t(15)=3.64$, $p<.01$) comparing perceptions for each representation were statistically significant.

SIA.H8. On average, group members perceived communication-flow representations as more useful in the development of generic information technology solutions than activity-flow representations (see ITSOLUT row in Table 1). The results of the paired samples *t* test ($t(15)=3.05$, $p<.01$) comparing perceptions for each representation were statistically significant.

PARTICIPANT OBSERVATION NOTES

The patterns of evidence listed below have been derived from the participant observation notes generated based on direct observation of process-redesign groups at work. They are referred to by “PON” (participant observation notes) codes that are later used for data triangulation. The patterns of evidence PON.H1, PON.H6 and PON.H8 provide support for the hypotheses H1, H6, and H8, respectively. These were the only patterns of evidence obtained from the analysis of participant observation notes that were relevant for testing the hypotheses—i.e., other patterns of evidence that emerged from the analysis (but that were unrelated to the hypotheses) are not listed below because they are not relevant for the study reported in this paper.

PON.H1. All groups generated activity-flow representations of their targeted processes before they generated communication-flow representations. This is seen as supporting hypothesis H1 based on the assumption that process redesign groups would generate first the process representation that they perceived as the least difficult to generate.

PON.H6. Of all the 37 process-redesign decisions made by the four groups as a whole, 23 process-redesign decisions (62.16%) were entirely based on communication-flow representations of their target processes. The other 14 process-redesign decisions were distributed as follows: 4 (10.81%) were entirely based on activity-flow representations of their target processes, and 10 (27.03%) were based on both types of representations. This is seen as supporting H6 because a Chi-square goodness-of-fit test of the distribution of process redesign decisions ($\chi^2(2, N=37)=15.3$, $p<.001$) suggests a statistically significant preference for the use of communication-flow representations when applying process-redesign guidelines.

PON.H8. All groups developed "generic" information technology "solutions" and respective rich pictorial representations entirely based on communication-flow representations of their target processes. This is seen as supporting hypothesis H8 based on the assumption that process-redesign groups would developed their "generic" information technology "solutions" and rich pictorial representations based on the process representation that they perceived as the most useful for those tasks.

UNSTRUCTURED INTERVIEW NOTES

The patterns of evidence listed below have been derived from the notes generated during unstructured interviews. They are referred to by "UIN" (unstructured interview notes) codes that are later used for data triangulation. The patterns of evidence UIN.$H1_0$, UIN.$H2_0$, UIN.$H3_0$, UIN.$H4_0$ and UIN.$H5_0$ do not support hypotheses H1, H2, H3, H4 and H5; that is, they provide support for the null hypotheses $H1_0$, $H2_0$, $H3_0$, $H4_0$ and $H5_0$ respectively. The patterns of evidence UIN.H6, UIN.H7 and UIN.H8 provide support for the hypotheses H6, H7 and H8, respectively.

UIN.$H1_0$. There was no clear majority perception as to whether communication-flow representations were easier or more difficult to generate than activity-flow representations.

UIN.$H2_0$. There was no clear majority perception as to whether communication-flow representations were easier or more difficult to understand than activity-flow representations.

UIN.$H3_0$. Most group members perceived communication-flow representations as more accurate than activity-flow representations. They generally explained their perception by pointing out that communication-flow representations provided more accurate depictions of the elements that seemed to flow the most in their processes, which they often referred to as "data" or "information." The following quote illustrates this: "*For certain processes, both the workflow and data-flow representations are accurate. However, they are not accurate for all processes. Our project consisted of movement of both work and data […] the work flow diagram depicts the movement of material within different functions […]. They where depicted clearly and in the proper order with correct time frame by the functional time line. Our project also consisted of a variety of data movement[s] like writing the request mutually agreed specification, SOP, and generating the final report […]. The [communication-] flow diagram by far more accurately depicted these data movement[s] than the functional time line.*"

UIN.$H4_0$. There was no clear majority perception as to whether communication-flow representations were more or less complete than activity-flow representations.

UIN.H5. Most group members perceived communication-flow representations as more useful in the identification of opportunities for improvement than activity-flow representations. They generally explained their perception by pointing out that communication-flow representations had not "caged" them into thinking in an "artificially sequential" manner, which was necessary for the redesign of the flow of "data" or "information" within a process. The following quote provides an illustration of this perception: "*The [activity-flow] diagram does not visibly show any wasted effort […] because the [communication-flow diagram] does not show actual tasks[;] it allows one to be more creative than being limited by a particular sequence. In the [communication-flow diagram] sequences aren't greatly represented […] so you do not get in the mindset of following a specific sequence. We can see what is needed, where to get information from, and it's up to us to define the sequence later.*"

UIN.H6. Most group members perceived communication-flow representations as more useful in the application of process redesign guidelines than activity-flow representations. They generally explained their perception by pointing out that communication-flow representations were better visual aids in the identification of problems in connection with the flow of "data" or "information," which were more frequently observed, and where process-redesign guidelines could be easily applied. This is illustrated by the following quote: "*The workflow representation shows a chronological view. Thus, it is easier to conceptualize the process at first. This will give a quick picture in order to understand the process […] [However,] by utilizing the [communication-] flow [representation], it was [easier] to see the excessive data flowing between the customer and the employees of ACD.*"

UIN.H7. Most group members perceived communication-flow representations as more useful in the in the visualization of process changes than activity-flow representations. They generally explained their perception in the same way as they explained their perception that communication-flow representations were more useful in the application of process-redesign guidelines, as the following quote suggests: "*It is easier to visualize the process changes using the data-flow representations than the workflow representations. With the data flow, you see that different data stores are receiving data from the same functional unit and sending data to the same or different functions. Based upon the data flow representation, it is easy to determine that all of the data stores are not needed.*"

UIN.H8. Most group members perceived communication-flow representations as more useful in the development of generic information technology solutions than activity-flow representations. They generally explained their perception by pointing out that, since the generic information-technology solution automated the flow of communication within a process, the communication-flow representation was particularly suited for its development. The following quote illustrates this: "*[Communication-flow representations give] a much better guideline for development of generic IT solutions than workflow representations. In our case, we used the new [communication-flow representation] and easily converted it to a generic IT solution. We had three main data stores. The first one was used for interaction between customer and ACD employees (in creation of RFS, MAS, SOP). This was easily changed to an asynchronous Web-based communication that was connected to a database management system. The second data store was used by the product technician for performing the test. This was replaced by the Automation system. The last data store stored manual results of lab which was replaced by the Lab Information Management System. This also provided the data needed for the Vice President to finalize the report for the customer and adhere to the ISO 9002 standard.*"

SUMMARY OF EVIDENCE IN SUPPORT AND AGAINST THE HYPOTHESES

Table 2 summarizes evidence in connection with the hypotheses, showing individual patterns of evidence in support of and against the hypotheses. Evidenced against the hypotheses H1, H2… is defined as evidence in support of the respective null hypotheses $H1_{0,}$ $H2_{0}$…

	Survey instrument answers	Participant observation notes	Unstructured interview notes
H1		PON.H1	
$H1_0$	SIA.$H1_0$		UIN.$H1_0$
H2			
$H2_0$	SIA.$H3_0$		UIN.$H3_0$
H3			
$H3_0$	SIA.$H2_0$		UIN.$H2_0$
H4			
$H4_0$	SIA.$H4_0$		UIN.$H4_0$
H5	SIA.H5		UIN.H5
$H5_0$			
H6	SIA.H6	PON.H6	UIN.H6
$H6_0$			
H7	SIA.H7		UIN.H7
$H7_0$			
H8	SIA.H8	PON.H8	UIN.H8
$H8_0$			

Table 2. Individual Patterns of Evidence in Support of and against the Hypotheses

(Evidence against H1, H2… = Evidence in support of the null hypotheses $H1_0$, $H2_0$…)

The evidence presented in Table 2 is grouped based on its source and indicated by specific acronyms that indicate the source of each piece of evidence—survey instrument answers (SIA), participant observation notes (PON), and unstructured interview notes (UIN). Empty cells indicate that a thorough search revealed the absence of patterns of evidence from a particular source in connection with the respective hypotheses.

DISCUSSION

The patterns of evidence summarized in the previous section provide weak support for hypothesis H1, no support for hypotheses H2, H3 and H4, and general support for hypotheses H5, H6, H7 and H8. This is summarized in Table 3 for convenience. Since the hypotheses were developed based on the communication-flow optimization model, it can be concluded that the patterns of evidence also provide moderate support for the model, reinforcing some elements the model but not others.

Hypothesis	Assessment
H1: Process-redesign group members will perceive communication-flow representations of business processes as more difficult to generate than activity-flow representations.	Weak support
H2: Process-redesign group members will perceive communication-flow representations of business processes as more difficult to understand than activity-flow representations.	Not supported
H3: Process-redesign group members will perceive communication-flow representations of business processes as less accurate than activity-flow representations.	Not supported
H4: Process-redesign group members will perceive communication flow representations of business processes as less complete than activity flow representations.	Not supported
H5: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the identification of opportunities for improvement than activity-flow representations.	Supported
H6: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the application of process redesign guidelines than activity-flow representations.	Supported
H7: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the visualization of process changes than activity-flow representations.	Supported
H8: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the development of generic information technology solutions than activity-flow representations.	Supported

Table 3. Assessment of the Hypotheses

Inconsistent with the model's predictions, process-redesign group members did not seem to perceive communication-flow representations of processes as less accurate, more difficult to understand, and less complete than activity-flow representations. In fact, evidence from both survey-instrument answers (SIA.$H2_0$) and unstructured interview notes (UIN.$H2_0$) suggest that communication-flow representations were perceived as significantly more accurate than activity-flow representations.

Also inconsistently with the model's predictions, process-redesign group members did not seem to perceive communication-flow representations of processes as more difficult to generate than activity-flow representations. Nevertheless, all groups spontaneously generated activity-flow representations of their targeted processes before they generated communication-flow representations (PON.H1).

The above findings put into question the communication-flow optimization model's assertion that activity-flow representations are better aligned with the way humans are cognitively programmed to envision "action" in the physical sense, and its claim that such cognitive alignment is one of the reasons why activity-flow representations and related process-redesign guidelines are so widely used today.

On the other hand, consistent with the communication-flow optimization model's predictions, process-redesign group members perceived communication-flow representations of business processes as more useful than activity-flow representations in the following aspects: identification of opportunities for improvement, application of process-redesign guidelines, visualization of process changes, and development of generic information-technology solutions (SIA.H5, SIA.H6, SIA.H7, SIA.H8, UIN.H5, UIN.H6, UIN.H7, UIN.H8). Also consistent with the communication-flow optimization model's predictions, the distribution of process-redesign decisions suggested a statistically significant preference for the use of communication-flow representations when applying process-redesign guidelines (PON.H6), and all groups developed "generic" information-technology "solutions" and respective rich pictorial representations entirely based on communication-flow representations of their target processes (PON.H8).

The above findings support the communication-flow optimization model's predictions that process redesign group members will prefer communication-flow representations particularly as the project moves from process analysis to process redesign, arguably due to the heavy role that information technologies are likely to play on process-redesign implementations, and the consequent need to address the flow of communication in the processes targeted for redesign.

It is clear that much more research is needed to further test and refine the communication-flow optimization model. Notably, this study suggests that the widespread use of activity-flow representations may be more due to current habits reinforced by consulting companies and management gurus, as argued by Kock and McQueen (1996), than to a cognitive predisposition toward those types of representations, as argued by the communication-flow optimization model. This issue is addressed below in our discussion of implications for future research and practice.

CONCLUSION

This study builds on the communication-flow optimization model and compares two key types of business process representations in the context of actual process-redesign projects. Empirical evidence collected and analyzed through a quasi-experimental action research project suggests that perceived accuracy is approximately 34% higher in communication-flow representations of processes in contrast to activity-flow representations. That empirical evidence also suggests that perceived usefulness in the identification of opportunities for improvement is about 22% higher in communication-flow representations; perceived usefulness in the application of process redesign guidelines is about 23% higher; perceived usefulness in the visualization of process changes is about 34% higher; and perceived usefulness in the development of generic IT solutions is about 38% higher in communication-flow representations in contrast to activity-flow representations.

While the above findings are consistent with the communication-flow optimization model and provide general support for the model, some other findings were not. Contrary to what is predicted based on the model, process-redesign group members did not perceive communication -flow representations as more difficult to generate than activity-flow representations, nor did they perceive communication-flow representations to be less accurate, more difficult to understand, or less complete than activity-flow representations. Interestingly, these findings suggest that communication-flow representations may be even more desirable than predicted by the model, since some of the disadvantages associated with them do not seem to be as significant as initially predicted.

As previously mentioned, the above findings may be seen as putting into question the model's claim that activity-flow representations are better aligned with the way humans are cognitively programmed to envision "action" in the physical sense than communication-flow representations. However, another explanation could be invoked—one that would not require substantial revisions of the key underlying assumptions of the model. That explanation is that even though activity-flow representations are indeed seen as more natural than their activity-oriented counterparts, the information-intensive nature of most processes today (Drucker, 1993; Kock & McQueen, 1996; Kock et al., 1997; Kock & Murphy, 2001) forces individuals into adapting their way of thinking about processes—toward thinking of processes as webs of communication interactions—and thus counterbalances that naturalness effect. This explanation is consistent with the perception by process-redesign group members in this study that communication-flow representations are approximately 8% more difficult to generate than activity-flow representations. Such difference, while statistically insignificant given the sample size, has a noteworthy effect size of about .31. One possible way in which this alternative explanation can be tested is by assessing whether workers involved in less information-intensive processes perceive communication-flow representations to be more difficult to generate than activity-flow representations to a larger extent than workers in more information-intensive processes. That is, in the test of the alternative explanation, information-intensiveness in the processes targeted for redesign would have to be measured and tested for moderating effects on other variables.

This study suggests one key area of future research in connection with the communication-flow optimization model the investigation of the impact of using either communication-flow or activity-flow representations in process redesign projects, but not both (as in this study). This would provide the basis on which researchers could more clearly assess the advantages and disadvantages of one type of representation over and against the other, as this research design would be less likely to be influenced by interaction effects in connection with repeated-measures research designs (Drew & Hardman, 1985; Rosenthal & Rosnow, 1991) such as the one employed in this study. It seems, from the findings of this study, that communication-flow representations may provide a complete and advantageous alternative to activity-flow representations.

Another area of future research relates to the development, refinement and investigation (based on the findings of this study) of methods and techniques that are related to but go beyond the scope of business process redesign. One area in which this line of inquiry may be fruitful is systems analysis and design (Dennis & Wixom, 2000), as there have been research studies in that past (see, e.g., Chuang & Yadav, 2000) suggesting that some new and increasingly popular systems-analysis and design methods and techniques may suffer from the same problems associated with methods and techniques used in process redesign that rely too heavily on activity-flow representations (and too lightly on communication-flow representations).

One example of the above situation is the recent success of object-oriented programming, which has led to the emergence and increasing use of object-oriented methods and techniques for systems analysis and design. In spite of much industry support, the scope of use of object-oriented methods and techniques in systems analysis and design is still not very significant when compared with that of object-oriented methods and techniques in programming. Chuang & Yadav (2000) argue that this is due to object-oriented analysis' excessive activity orientation, which they addressed by developing and validating, with positive conceptual results, a new methodology that applies modified object-oriented methods and techniques to the solution of systems analysis and design problems. This new methodology shifts the emphasis away from activities, as defined in this paper, and onto how communication takes place in processes.

This research has key implications for managers involved in operational-level process-redesign projects. One key implication is that those managers should carefully analyze the focus of their projects, especially when the goal is to obtain quality and productivity improvements through the redesign of individual processes. While a focus on activities and their flow may be advocated by proponents of popular activity flow-based methods such as large consulting companies and recognized management "gurus" such as Hammer (1996) and Harrington et al. (1998), this study suggests that such focus is likely to contribute to less-than-optimal outcomes. Managers should strongly consider moving away from that focus and toward a focus on communication flows and process redesign-related techniques. This is particularly important in broad projects that target primarily service processes, where the flow of materials is minimal, such as the recent organization-wide initiatives by large corporations and government branches to improve acquisition practices (Graves, 2001). In projects of such breadth and magnitude, even single-digit success rate increases can lead to savings in the range of millions of dollars.

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Determining the Best Loci of Knowledge, Responsibilities and Decision Rights in Major Acquisition Organizations

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ABSTRACT

The DoD is a large, bureaucratic, rule-intensive organization that may not be suited well for its environment. Building upon prior research of acquisition centralization and knowledge dynamics, we employ computational methods to assess the behavior and performance of different organizational designs in varying environments. Our results reinforce Contingency Theory and suggest particular characteristics of different acquisition environments make one organizational form relatively more or less appropriate than another. Practically, answers to our research questions have direct and immediate application to acquisition leaders and policy makers. Theoretically, we generalize to broad classes of organizations and prescribe a novel set of organizational design guides.

INTRODUCTION

Acquisition is big business. The US Department of Defense (DoD) alone executes routinely eleven-figure budgets for research, development, procurement and support of weapon systems, for instance. Acquisition is also a rule-intensive business. In addition to myriad laws governing federal acquisition in the US, a plethora of regulations specify—in great detail often—how to accomplish the planning, review, execution and oversight of Government acquisition programs, large and small, sole-source and competitive, military and commercial (Dillard, 2003). Due in great part to the large size and many rules associated with Defense acquisition in particular, the organizations responsible for DoD acquisition activities tend to be large and rule-intensive themselves, reflecting the kinds of centralized, formalized, specialized and oversight-intensive forms corresponding to the classic Machine Bureaucracy from Organization Theory (e.g., see Mintzberg, 1979). The problem is this classic organizational structure is known well to be exceptionally poor at responding to change. In the context of military transformation, such a problem should be clear and compelling. Arguably, one or more, superior, organizational approaches must be available to replace the current acquisition organization. But which, if any, is most appropriate? On what basis should acquisition leaders and policy makers choose between such competing organizational forms? What evidence supports claims of superiority for one organizational approach versus another? Questions such as these are difficult to answer through most research methods employed today to study acquisition organizations (e.g., case study, survey, action).

The bureaucratic nature of the DoD Acquisition Organization did not emerge recently, nor did it materialize by design. Rather, it reflects the cumulative accretion of laws, regulations, rules and hierarchical levels over considerable time. If only the organization could be changed and evaluated—say through assessment of four alternate organizational structures—then one could assess the relative performance of the new organizational designs versus the current form and recommend transformation toward the best performer. But, clearly the set of problems and actors in the changed organizations would differ from those associated with the original and with one another; that is, there is no way to impose controls over such a study (e.g., internal validity is compromised). This is one reason why so many acquisition research projects produce so little new knowledge. Alternatively, such controls can be imposed easily through laboratory experimentation. Yet, the simplified nature and laboratory context of experiments fail to capture the size, scope and complexity of the acquisition organization (e.g., external validity is compromised). This is another reason why so many acquisition research projects produce so little new knowledge. However, by combining the best features of laboratory experimentation (e.g., experimental controls) with field methods (e.g., large-scale and complex behaviors), one can design and conduct a study of acquisition organizations that reflects both internal and external validity.

This is the approach of computational experimentation: using sophisticated and validated computer models of organizations to assess the behavior and performance of different organizational designs. Computational Organization Theory (COT; see Carley & Prietula, 1994) provides a set of methods and tools to enable this approach. In particular, using the methods and tools associated with the Virtual Design Team (VDT) Research Group at Stanford, computational models of organizations are driven by well-accepted organization theory and are validated by extensive and repeated field studies. This validation provides considerable confidence that computational results reflect the likely behaviors and performance of the acquisition organizations they model and emulate.

The research described in this article involves the application of VDT methods and tools to study acquisition organizations. In particular, we model and simulate the behavior of organizations associated with major defense acquisition programs in the DoD. We provide both answers to and insights into how such organizations can be changed to improve performance. Some of the key organizational design variables of interest pertain to the bureaucratic nature of the organization and follow from recent research to investigate centralization (Dillard, 2003). For instance, factors such as *centralization, formalization, specialization, hierarchical layers* and the like can be manipulated—individually as well as in combination—under controlled and replicated conditions to assess the performance of acquisition organizations in different forms. This follows recent, complementary research using computational organization theory in the domain of military command and control (Nissen & Buettner, 2004; Nissen, 2005a, b). Considerations such as the number, frequency and level of acquisition reviews, adaptability and flexibility of acquisition organizations, and risk-versus-project-duration of acquisition programs are primary in this study. The key research question is: How can organizations responsible for major acquisition programs be redesigned to improve performance?

The significance of this approach is twofold. First, answers to the research question have direct and immediate application to acquisition leaders and policy makers. Such answers address a serious and immediate problem, revealing insights into the behaviors of major acquisition organizations that are too complex and dynamic to be understood well or directly. They illuminate the kinds of changes acquisition organizations can make to balance competing performance measures (e.g., adaptability & flexibility vs. project risk & duration). They can explain—in a theoretically grounded manner—many different cases of acquisition success as well as failure. They can also provide overarching theory to help promote the former and obviate the latter in future acquisition programs.

Second, this research project demonstrates the efficacy of a new approach to studying acquisition organizations. It enables leaders, policy makers and analysts to answer “how much” questions such as: How much centralization, formalization and specialization is best? What fraction of commercial off-the-shelf equipment would be ideal? What level of concurrency between development and production provides the best combination of cost, schedule, performance and risk? Such questions are not answered well today in terms of acquisition organizations. This leaves acquisition decision makers today with no reliable means to address such questions.

The balance of the article begins with a focused review of the literature relevant to this study. We follow with discussion of our research design and description of the computation model developed to represent and emulate the acquisition organization. The article turns then to discuss results of our computational experiments. Conclusions, implications and recommendations for future research close the article, along with a rich set of references for deeper exploration into the research on which this article builds and contributes. We also include two appendices to provide details of our computational models.

BACKGROUND

This focused review of the literature relevant to our study is organized into three parts: 1) the acquisition organization, 2) organization theory, and 3) computational experimentation.

The Acquisition Organization

Of particular interest to the authors is the realm of DoD program management, where research and development dollars are expended to invent or advance warfighting capability. While US weaponry is considered some of the best in the world, the major acquisition projects to acquire them are often fraught with cost and schedule growth. They even fail at times to meet specifications or to provide the capabilities desired. Since implementation of the Goldwater-Nichols Act legislation in the late 1980s, major defense acquisition organizations (e.g., program management offices) have operated under a four-tiered decision structure.

For major acquisitions, the current policy makes clear that the Under Secretary of Defense for Acquisition, Technology and Logistics is the Milestone Decision Authority responsible for the overall program: Described in the DODI 5000.1:

> 3.4 The Milestone Decision Authority (MDA) is the designated individual with overall responsibility for a program. The MDA shall have the authority to approve entry of an acquisition program into the next phase of the acquisition process and shall be accountable for cost, schedule, and performance reporting to higher authority, including Congressional reporting. (USD(AT&L), 2003)

And three levels down the hierarchy, Program Managers (PMs) are described as:

> 3.5.1 the designated individual with responsibility for and authority to accomplish program objectives for development, production, and sustainment to meet the user's operational needs. The PM shall be accountable for credible cost, schedule, and performance reporting to the MDA. (USD(AT&L), 2003)

Thus, the Program Manager and Milestone Decision Authority share responsibility for development and oversight of a program. Further guidance under the DoD Instruction 5000.1 provides:

> 4.3.1.1 There is no *one* best way to structure an acquisition program to accomplish the objective of the Defense Acquisition System. MDAs and PMs shall tailor program strategies and oversight, including documentation of program information, acquisition phases, the timing and scope of decision reviews and decision levels to fit the particular conditions of that program, consistent with applicable laws and regulations and the time-sensitivity of the capability need. (USD(AT&L), 2003)

However, while the wording above might indicate that the MDA and PM plan jointly or collaborate in some way on program strategy, there are, in fact, both a Component Acquisition Executive and Program Executive Officer in the hierarchy between them, and direct communication between MDA and PM is infrequent. The four tiers of major program command and control and typical grade/ranks of positions are shown in Figure 1.

Figure 1. DoD Decision Hierarchy for Major Defense Acquisition Programs
(adapted from DAU, 2004)

MDA PMs lead Program Management Offices (PMOs). PMOs vary greatly in size. A typical range of government-assigned workers is generally between 50 and 100 individuals dedicated to the day-to-day efforts. An expanding network of other government agency players, multi-tier industry contractors, and other participants can multiply this figure many times (Dillard, 2004). While all stakeholders represent different parts of the enterprise, here we refer to this central government organizational entity—the government PMO—as the *acquisition organization*.

At the PMO level, several alternatives for the organization exist. In most cases, the offices are comprised of permanently assigned "core" personnel, and temporarily assigned co-located "matrix" personnel on loan from commodity systems commands. These are personnel typically arrayed by functional area within the PMO (as shown in Figure 2). A significant number of on-site support contract personnel may be present as well.

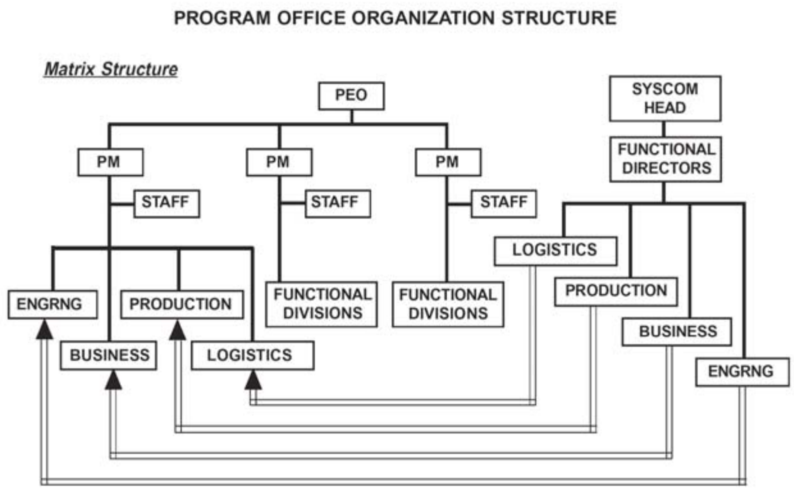

Figure 2. Typical, Matrixed Program Management Office Structure (adapted from DAU, 2004)

Somewhat less formally, programs also organize internally in ad hoc teams oriented on specific areas of each project. This stems largely from DoD initiatives over the last 10 years to implement Integrated Product and Process Development (IPPD) using Integrated Product Teams (IPT). This management philosophy emphasizes the potential of collective knowledge via small organizations with cross-functional or multi-disciplinary members (OUSD, 1998). Interestingly, the ideas in this IPPD/IPT philosophy of work implementation and problem solving are also embodied and magnified in emerging thought regarding command and control (C2) in tactical military organizations. The text *Power to the Edge* recognizes the benefit of using information-age technology to transfer knowledge and power to the point of an organization's interaction with its environment (Alberts & Hayes, 2003).

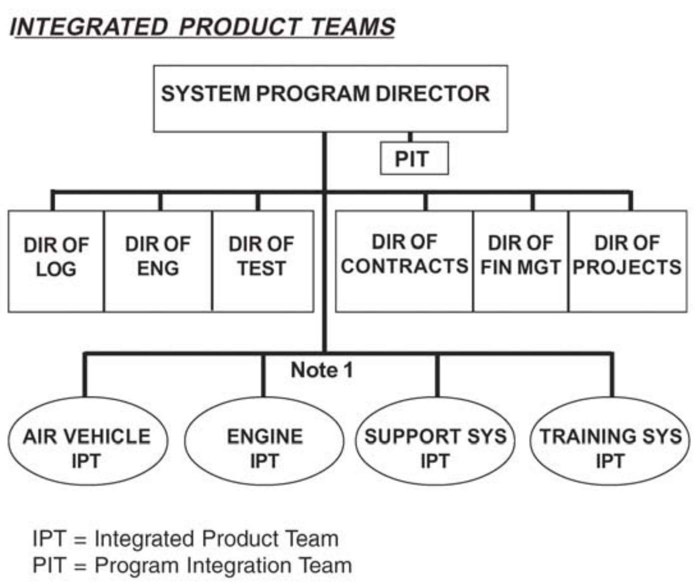

Figure 3. Example (Aircraft) PMO IPT Structure (adapted from DAU, 2004)

Another concept pertinent to our introduction is that of work and organizational hierarchy. Nobel Prize winner Herbert Simon argues, from his observation of complexity in things both natural and artificial, that complex systems evolve from simple systems. And they do so more rapidly when there are stable, intermediate forms or sub-systems (like modules or "units of action"). Moreover, he argues the resulting evolution into the complex system will be hierarchic, including systems such as organizations (Simon, 1981). But an important observation is also made by Koestler, who studies hierarchies in social organizations. He notes that sub-systems exist only as entities relative to their positions in the hierarchy. He proposes the word "holon" to describe the hybrid nature of individual organizations within larger organizations/systems. Holons are unique and self-contained wholes to their subordinated parts. But at the same time, they are also dependent parts of the larger hierarchy (or "holarchy," as Koestler termed structures consisting of them). He views holons as autonomous, self-reliant units which have their own independence, and which cope with contingencies without asking higher authorities for instructions. Yet, they remain subordinate ultimately, subject to control from higher authorities. The term seems somewhat analogous to *edge* in the conceptualization of Edge organizations (Alberts & Hayes, 2003). Such concepts of unit knowledge, empowerment and relative autonomy within organizational structures are key to our design of various organizations for experimentation.

Organization Theory

Classic organization theory holds that organizational structures must change in response to contingencies of size, technology, environment and other factors. Indeed, it is accepted widely that, when faced with uncertainty (a situation with less information than is needed), the appropriate management response should be either to redesign the organization for the task at hand or to improve information flows and processing (Galbraith, 1973). Van Creveld (1985) applies this same principle to command and control of combat elements in war. He argues that the command structure must either create a greater demand for information (vertically, horizontally, or both) and increase the size and complexity of the directing organization, or it must enable the local forces to deal semi-independently with the situation. His central theme is that decentralized control is the superior method of dealing with uncertainty, whether with the task at hand or with transformation of the organization itself. Research by Van de Ven and Delbecq (1986) has shown further that as complexity and uncertainty increase, hierarchical management control and vertical communication strategies are considered inferior to less formal organizations with horizontal communication channels.

Another classical concept of organizational theory is Ashby's Law of Requisite Variety (Ashby, 1960). This states loosely that, in order to cope with the variety of challenges imposed by it, the internal capabilities of a system must be as diverse as those required by its environment. Organizational evolution and survival are dependent upon requisite variety, particularly in environmental contexts that are dynamic and unpredictable. This suggests, too, that the organization's structure and control strategy must be matched to its environment to enhance performance. Open and flexible management styles and processes are required often for dynamic market and technological conditions. Further, research by Burrell and Morgan (Morgan, 1997) indicates that any incongruence among management processes and the organization's environment tend to reduce organizational effectiveness.

What the cumulative research appears to support is that, for large, complex hierarchies such as the Department of Defense—which operate in today's environment of program complexity, evolving requirements, and rapidly changing technology—decentralized control and empowerment should be an organizational strength. Notwithstanding such cumulative research, however, organizational hierarchies persist (Leavitt, 2004). Indeed, for DoD acquisition in particular, the command structure has remained relatively stable since the late 1980s. Although the current command structure is arguably flatter and more streamlined now than it was in the Seventies and before, it remains fundamentally hierarchical, centralized and rule-driven. Only through the major reform initiatives of the 1980s and 1990s did the acquisition organization's "chain of command" become as streamlined as it now is (Packard Commission, 1986).

Computational Experimentation

Drawing heavily from Nissen and Buettner (2004), we assert that throughout the era of modern science, a chasm has persisted between laboratory and field research. On one side, the laboratory provides unparalleled opportunity for controlled experimentation. Through experimentation, the researcher can manipulate only a few variables of interest at a time and can minimize the confounding associated with the myriad factors affecting complex systems and processes in the field (Box et al., 1978; Johnson & Wichern, 1992). However, limitations of laboratory experimentation are known well (Campbell & Stanley, 1973) and are particularly severe in the domain of acquisition. In acquisition experimentation, such limitations center on problems with external validity. Laboratory conditions can seldom replicate the complexity, scope and scale of the physical organizations and systems of interest for research. Experiments also include problems with generalizability. Many experiments utilize samples of convenience (esp. university students) instead of working professionals. This practice calls into question how closely the associated experimental results are representative of acquisition behavior in operational organizations. These same concerns pertain also to analytical methods (e.g., mathematical analysis, optimization; see Chiang, 1984; Lapin, 1985). Most such methods use theoretical concepts as variables, not operationalized constructs. And, of course, analytical models do not involve real people, systems and organizations.

On the other side, field research provides unparalleled opportunity for realism (Denzin &, Lincoln, 1994). The researcher in the field can study full-scale artifacts in operational environments (Yin, 1994) and can minimize the abstraction away from working people, systems and organizations (Glaser & Strauss, 1967). However, limitations of field research are also known well (Campbell & Stanley, 1973) and are particularly severe in the acquisition domain. In acquisition field research, such limitations center on problems with internal validity. Field research affords little opportunity for controlled experimentation (cf. Cook & Campbell, 1979). Also, confounding data often results from the myriad influences on complex systems and organizations that cannot be isolated in the field. This diversity makes it difficult to identify and trace the causes of differential behaviors—better as well as worse—in acquisition.

As implied by the name, computational experiments are conducted via computer simulation. As such, they offer all of the cost and time advantages of computational analysis. But, computational experiments go beyond most simulations. Rigorous experimental designs are employed to capture the benefits of laboratory experimentation. The variables affecting physical systems and organizations in the field can be isolated and examined under controlled conditions. This type of analysis also addresses the internal validity and confounding limitations of field research. Yet, computational experiments can be conducted at a fraction of the cost and time required to set up and run experiments with human subjects in the laboratory. Further, through external validation, computational models can demonstrate fidelity emulation of the key qualitative and quantitative behaviors of the physical systems and organizations they represent. This ability addresses the problems with external validity and generalizability noted above.

It is important to note: computational modeling and simulation are not new techniques for the study of acquisition. For instance, a major DoD initiative called simulation-based acquisition has sought to educate the workforce about modeling and simulation (DSMC, 1998). And DoD policy has called for extensive use of modeling and simulation techniques in program planning and execution (Gansler, 1998). But, simulation-based acquisition has suffered to date from problems with internal and external validity alike. Such problems are not inherent to simulation methods or tools per se. Rather, they stem from models lacking theoretically rooted behaviors, externally validated results, and experimental controls. Our approach to computational experimentation obviates such problems deliberately.

Figure 4 illustrates the essential elements of computational experimentation as a research method. The top of the figure includes a shape to depict the bridge metaphor associated with this method, as it spans a wide gap between laboratory and field methods. From the left side of this "bridge," two arrows represent inputs to describe the behaviors of computational models. Organization theory, which is predicated upon many thousands of studies over the last half century, provides the basis for most such behaviors. Behaviors pertaining to organizational factors such as centralization, division of labor, task interdependence, function, coordination, formalization, technology and information processing from organization theory are captured well. Where extant theory does not address well a behavior of interest (e.g., knowledge flows), ethnographic and like immersive field studies (Bernard, 1998) are conducted to understand the associated organizational behaviors. Because organization theory is general and not based on any single organization, the associated behaviors have broad applicability across organizations in practice. This provides for the generalizability attainable through the method of computational experimentation.

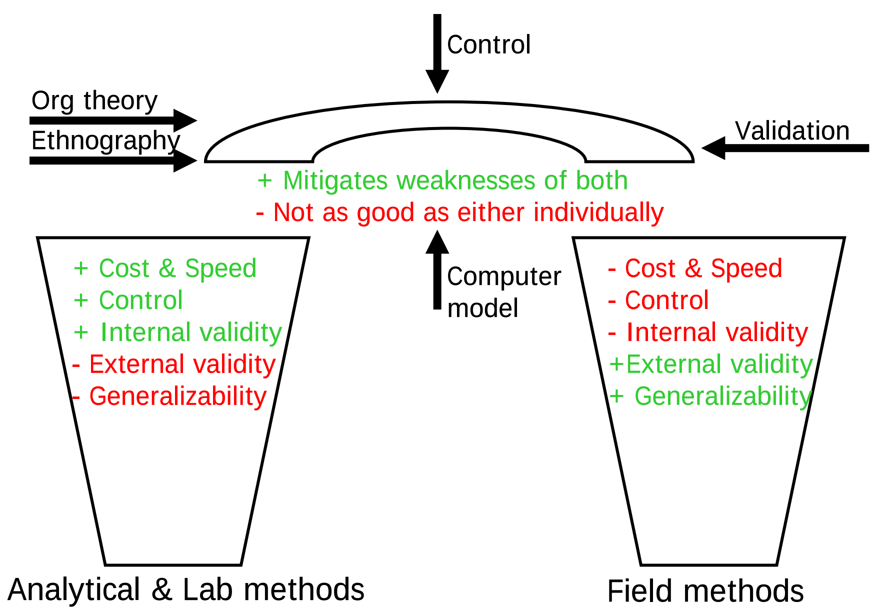

Figure 4. Bridge Method (adapted from Nissen & Buettner, 2004)

From the bottom of the “bridge,” an arrow represents the use of computer models to represent organizations and to emulate their key behaviors. Some variety exists in terms of specific implementations, but most computer models adhere to standards, norms and conventions associated with the COT field. The central goal is to develop computer models that emulate the key behaviors of organizations and to use such models to examine alternate methods of organization and coordination. As such, COT shares with acquisition a focus on many factors of importance.

From the right side of the “bridge” in the figure, one arrow represents a requirement in our approach for model validation. Through validation, the organizational behaviors emulated by computer models are examined and compared with those of operational organizations in the field. We view this comparison as essential, for it provides confidence that the behaviors emulated by the computer model have sufficient fidelity to mirror faithfully the behaviors of the operational organizations they represent. This provides for the external validity attainable through computational experimentation. It is important to note, not all COT models are subjected to such validation. Many researchers use computational models to conduct theorem-proving studies, which are valuable in their own right to demonstrate various aspects of organization theory. But without validation, researchers have difficulty making claims that such theory mirrors the behavior of organizations in the field. Hence, validation represents an important characteristic of distinguishing computational experimentation (as the research method described specifically in this article) from COT in general.

Finally, from the top of the “bridge,” an arrow represents the use of experimental controls in research. Following the same, rich set of experimental designs available to laboratory researchers (e.g., full-factorial, Latin Squares, blocking with replication), computational experimentation as a research method can be used to control myriad factors and to manipulate just one or a few variables at a time (e.g., searching for causality relations). Further, the same experimental design and setup can be replicated any number of times—for instance, using Monte Carlo techniques or other computational approaches to introduce variation. This provides for the internal validity attainable through computational experimentation. The combination of these “bridge” inputs—organization theory and ethnography, computer models, validation and control—allows the method of computational experimentation to be understood in terms of, and to indeed inherit, the various properties of its constituent elements.

Figure 4 illustrates also the bridging nature of computational experimentation as a research method. On the left side, we depict analytical and laboratory methods and we summarize their key advantages (e.g., low-cost & fast studies, good experimental control & internal validity) and disadvantages (e.g., poor external validity & generalizability). On the right side, we depict field methods in similar fashion to summarize their key advantages (e.g., good external validity and generalizability) and disadvantages (e.g., high cost & time consuming, poor experimental control & internal validity). Notice from their relative advantages and disadvantages how the two classes of research methods complement one another. Field methods are strong in the areas where analytical and laboratory methods are weak, and vice versa. As an alternate research method, computational experimentation mitigates weakness of both classes. For instance, it enables good experimental control and internal validity as in laboratory methods. It also promotes good generalizability and external validity as in field methods.

Nonetheless, every research method is flawed in some respects. In our present case, when used in isolation, computational experimentation is not as good as either method at its best. For instance, because computational experimentation uses computer models of people in organizations instead of real people, it is weaker in this respect than laboratory experimentation is. This same use of computer models instead of real people also makes computational experimentation weaker than field methods are. This is why we describe computational experimentation as a *bridge method*: it bridges the chasm between experimental and field research methods; yet, it serves best to complement, not to replace, such methods.

RESEARCH DESIGN

This discussion of the research design is organized into three parts: 1) agent-based modeling environment, 2) computational acquisition organization model, and 3) experimental design.

Agent-Based Modeling Environment

In this section, we build upon current advances in VDT research to describe the agent-based modeling environment used here for computational experimentation. Drawing heavily from Nissen and Levitt (2004), we first summarize the stream of research associated with VDT and then describe its modeling environment.

Virtual Design Team Research

The VDT Research Program (VDT, 2004) reflects the planned accumulation of collaborative research over two decades to develop rich theory-based models of organizational processes. Using an agent-based representation (Cohen, 1992; Kunz et al., 1998), micro-level organizational behaviors have been researched and formalized to reflect well-accepted organization theory (Levitt et al., 1999). Extensive empirical validation projects (e.g., Christiansen, 1993; Thomsen, 1998) have demonstrated representational fidelity and have shown how the emulated behaviors of VDT computational models correspond closely with a diversity of enterprise processes in practice.

The VDT research program continues with the goal of developing new micro-organization theory and of embedding it in software tools that can be used to design organizations in the same way that engineers design bridges, semiconductors or airplanes: through computational modeling, analysis and evaluation of multiple, alternate prototype systems. Clearly, this represents a significant challenge in the domain of organizations. Micro-theory and analysis tools for designing bridges and airplanes rest on well-understood principles of physics (e.g., involving continuous numerical variables, describing materials whose properties are relatively easy to measure and calibrate), and analysis of such physical systems yields easily to differential equations and precise numerical computing.

In contrast, theories describing the behavior of organizations are characterized by nominal and ordinal variables, with poor measurement reproducibility, and verbal descriptions reflecting significant ambiguity. Unlike the mathematically representable and analyzable micro-behaviors of physical systems, the dynamics of organizations are influenced by a variety of social, technical and cultural factors, are difficult to verify experimentally, and are not as amenable to numerical representation, mathematical analysis or precise measurement. Moreover, quite distinct from physical systems, people and social interactions—not molecules and physical forces—drive the behavior of organizations. Hence, such behaviors are fundamentally non-deterministic and difficult to predict at the individual level. Thus, people, organizations and business processes are qualitatively different from bridges, semiconductors and airplanes. And it is irrational to expect the former to ever be as understandable, analyzable or predictable as the latter. This represents a fundamental limitation of the approach.

Within the constraints of this limitation, however, we can still take great strides beyond relying upon informal and ambiguous, natural-language textual description of organizational behavior (e.g., the bulk of extant theory). For instance, the domain of organization theory is imbued with a rich, time-tested collection of micro-theories that lend themselves to qualitative representation and analysis. Examples include Galbraith's (1977) information-processing abstraction, March and Simon's (1958) bounded rationality assumption, and Thompson's (1967) task-interdependence contingencies. Drawing from this theory base, we employ symbolic (i.e., non-numeric) representation and reasoning techniques from established research on artificial intelligence to develop computational models of theoretical phenomena. Once formalized through a computational model, the symbolic representation is "executable," meaning it can emulate the dynamics of organizational behaviors.

Even though the representation is qualitative (e.g., lacking the precision offered by numerical models), through commitment to computational modeling, it becomes semi-formal (e.g., different people viewing the model can agree on what it describes), reliable (e.g., the same sets of organizational conditions and environmental factors generate the same sets of behaviors), and explicit (e.g., much ambiguity inherent in natural language is obviated). Particularly when used *in conjunction with* the descriptive natural language theory of our extant literature, this represents a substantial advance. Further, once a model has been validated to emulate accurately the qualitative behaviors of the field organization it represents, it can be used to examine a multitude of cases (e.g., many more and diverse than observable in practice) under controlled conditions (e.g., repeating the same events multiple times, manipulating only one or a few variables at a time through repeated trials, stopping the action for interpretation). These features alone offer great promise in terms of theory development and testing.

Additionally, although organizations are inherently less understandable, analyzable and predictable than physical systems are, and the behavior of people is non-deterministic and difficult to model at the individual level, it is known well that individual differences tend to average out when aggregated cross-sectionally and/or longitudinally. Thus, when modeling aggregations of people in the organizational context (e.g., work groups, departments, firms), one can augment, with certain aspects of numerical representation, the kind of symbolic model from above. For instance, the distribution of skill levels in an organization can be approximated—in aggregate—by a Bell Curve; the probability of a given task incurring exceptions and requiring rework can be specified—organization wide—by a distribution; and the unpredictable attention of a worker to any particular activity or event (e.g., new work task, communication, request for assistance) can be modeled—stochastically—to approximate collective behavior. As another instance, specific organizational behaviors can be simulated hundreds of times—such as through Monte Carlo techniques—to gain insight into which results are common and expected versus those that are rare and exceptional.

Of course, applying numerical simulation techniques to organizations is nothing new (e.g., see Law & Kelton, 1991). But this approach enables us to *integrate* the kinds of dynamic, qualitative behaviors emulated by symbolic models with quantitative aggregate dynamics generated through discrete-event simulation. It is through such integration of qualitative and quantitative models—bolstered by strong reliance upon well-established theory and commitment to empirical validation—that our approach diverges most from extant research methods and offers new insight into the dynamics of organizational behavior.

VDT Modeling Environment

Here we provide a brief overview of the VDT modeling environment. The development and evolution of VDT has been described in considerable detail elsewhere (e.g., Cohen, 1992; Christiansen, 1993; Jin & Levitt, 1996; Thomsen, 1998; Kunz et al., 1998; Levitt et al., 1999; Nogueira, 2000; VDT, 2004), so we do not repeat such discussion here. The VDT modeling environment has been developed directly from Galbraith's information-processing view of organizations. This information-processing view has two key implications (Jin & Levitt, 1996). The first is ontological: we model knowledge work through interactions of *tasks* to be performed, *actors* communicating with one another and performing tasks, and an *organization structure* that defines actors' roles and that constrains their behaviors. In essence, this amounts to overlaying the task structure on the organization structure and to developing computational agents with various capabilities to emulate the behaviors of organizational actors performing work.

Figure 5 illustrates this view of tasks, actors and organization structure. As suggested by the figure, we model the organization structure as a network of reporting relations which can capture micro-behaviors such as managerial attention, span of control and empowerment. We represent the task structure as a separate network of activities, which can capture organizational attributes such as expected duration, complexity and required skills. Within the organization structure, we further model various *roles* (e.g., marketing analyst, design engineer, manager), which can capture organizational attributes such as skills possessed, level of experience and task familiarity. Within the task structure, we further model various sequencing constraints, interdependencies and quality/rework loops—which can capture considerable variety in terms of how knowledge work is organized and performed.

As suggested also by the figure, each actor within the intertwined organization and task structures has a queue of information tasks to be performed (e.g., assigned work activities, messages from other actors, meetings to attend) and a queue of information outputs (e.g., completed work products, communications to other actors, requests for assistance). Each actor also processes such tasks according to how well the actor's skill set matches those required for a given activity, the relative priority of the task, the actor's work backlog (i.e., queue length), and how many interruptions divert the actor's attention from the task at hand. Collective task performance is constrained further by the number of individual actors assigned to each task, the magnitude of the task, and both scheduled (e.g., work breaks, ends of shifts, weekends and holidays) and unscheduled (e.g., awaiting managerial decisions, awaiting work or information inputs from others, performing rework) downtime.

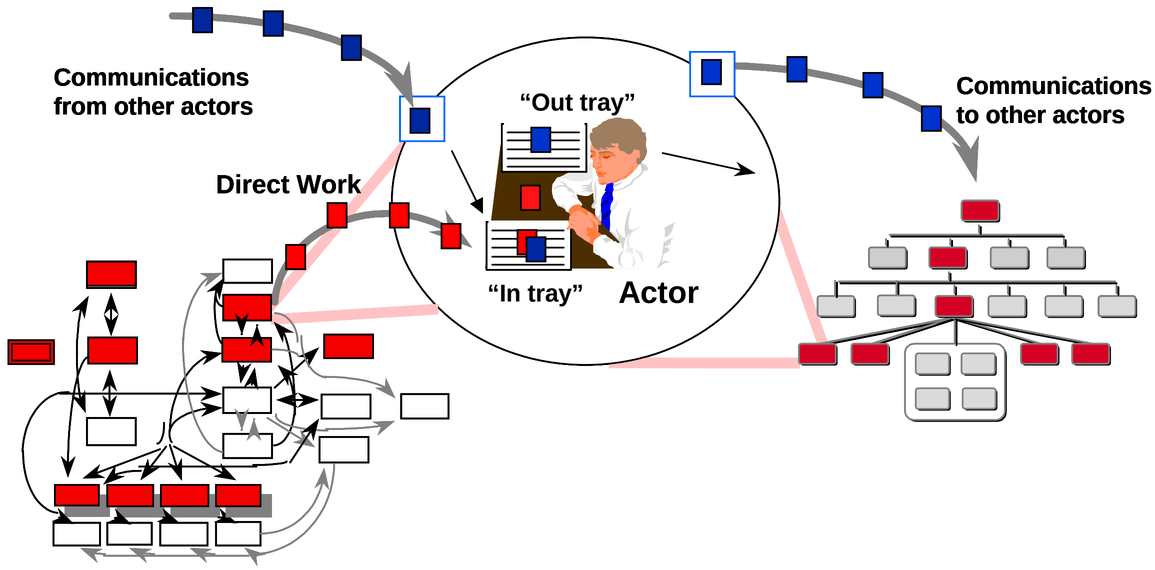

Figure 5. VDT Information Processing View of Knowledge Work (adapted from Nissen & Levitt, 2004)

The second implication is computational: both primary work (e.g., planning, design, management) and coordination work (e.g., group tasks, meetings, joint problem solving) are modeled in terms of *work volume.* This construct is used to represent a unit of work (e.g., associated with a task, a meeting, a communication) within the task structure. In addition to symbolic execution of VDT models (e.g., qualitatively assessing skill mismatches, task-concurrency difficulties, decentralization effects) through micro-behaviors derived from organization theory, the discrete-event simulation engine enables (virtual) process performance to be assessed (e.g., quantitatively projecting task duration, cost, rework, process quality).

Clearly, quantitative simulation places additional burden on the modeler in terms of validating the representation of a knowledge-work process, which generally requires fieldwork to study an organization in action. The VDT modeling environment benefits from extensive fieldwork in many diverse enterprise domains (e.g., power-plant construction and offshore drilling, see Christiansen, 1993; aerospace, see Thomsen, 1998; software development, see Nogueira, 2000; healthcare, see Cheng & Levitt, 2001; others). Through the process of "backcasting"—predicting known organizational outcomes using only information that was available at the beginning of a project—VDT models of operational enterprises in practice have demonstrated dozens of times that emulated organizational behaviors and results correspond qualitatively and quantitatively to their actual counterparts in the field (Kunz et al., 1998).

Viewing VDT as a validated model of project-oriented knowledge work, researchers have begun to use this dynamic modeling environment as a "virtual organizational testbench" to explore a variety of organizational questions, such as effects of distance on performance (Wong & Burton, 2000) or to replicate classic empirical findings (Carroll & Burton, 2000). Thus, the VDT modeling environment has been validated repeatedly and longitudinally as representative of both organization theory and enterprises in practice. This gives us considerable confidence in its results. Moreover, VDT is designed specifically to model the kinds of knowledge work and information-processing tasks that comprise the bulk of acquisition processes.

Computational Acquisition Organizational Model

In our experimental efforts, we use the VDT modeling environment to represent work associated with a three-tier acquisition organization. This follows our discussion above, and it is representative of many DoD service-level environments today (e.g., where several project offices report into one program executive “Portfolio Manager” and then up to a Component Acquisition Executive, and often into yet another level of decision-making). VDT is capable of modeling large, complex, operational organizations in great detail; it has been demonstrated repeatedly to emulate well the associated behaviors of organizations in the field. But, using a high-level model as such helps us to maintain the focus of this expository article on techniques of VDT modeling and computational experimentation (which represents one of our primary contributions), and not to get lost in the details of the organization itself. We first describe the VDT representation and then illustrate how a full-factorial computational experiment can be performed upon it.

VDT Acquisition Model

Figure 6 presents a screenshot of the VDT acquisition program model. The model is comprised of five developmental system acquisition projects (i.e., denoted as lightly colored boxes). Both concurrent and sequential projects/tasks are depicted in the model, and interdependencies are represented among them. The model depicts a simple and abbreviated series of coordinated research and development efforts which are aligned to deliver an Advanced Strike capability integrated into a mobile platform and, subsequently, are enhanced with an evolutionary block of capability. It is but a representative subset of what could be a larger, more complex, and more detailed representation of such a program.

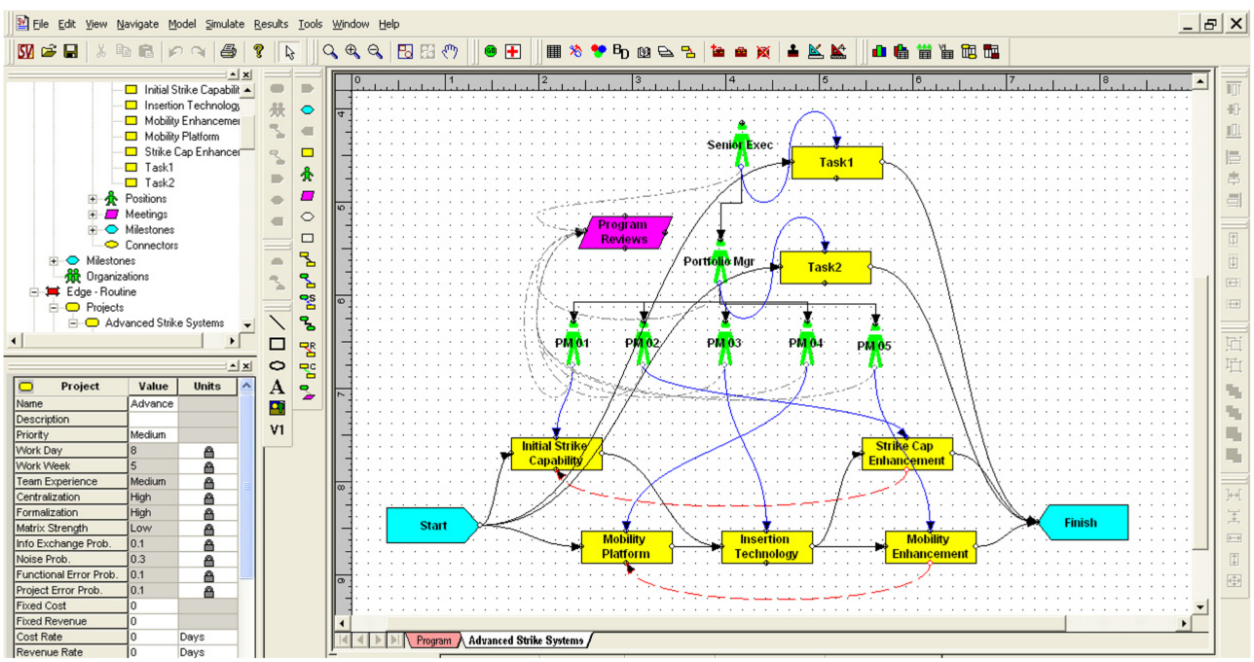

Figure 6. VDT Acquisition Model Screenshot

The coordination links (i.e., denoted by light dashed lines) connecting the coordinated tasks or projects denote reciprocal task interdependencies (Thompson, 1967), which suggest they must be coordinated closely in both planning and execution. For example, integration of strike capabilities into a mobile platform requires coordination among engineers for interface and configuration control of hardware, software, and other factors. VDT emulates the added coordination effort associated with such reciprocal task interdependencies. The rework links (i.e., denoted by dark dashed lines) connecting tasks from different mission phases denote sequential task dependencies, which suggest the predecessor activities must be accomplished effectively in order for the successors to perform well. Strike and Mobility Enhancements, for instance, depend heavily upon success of the Initial Strike and Mobility Platform efforts. To the extent that such predecessor work is not completed or not accomplished effectively, certain aspects may have to be reanalyzed to correct any major deficiencies.

The people icons depict organizations and are arranged in terms of the command-and-control, or decision-making, hierarchy. People icons represent one or more human resources, specified in Full Time Equivalents (FTEs), which have particular capabilities, skill levels and roles. Where a skilled actor's capability matches that required for an acquisition task, the resource is likely to perform it competently and within the time required. If the actor has greater or lesser skill, the time required to perform the task can be appreciably shorter or longer, and the competency of performance can be notably better or worse, respectively. Where an actor does not possess the required capability at all, the task will be in jeopardy. Such relationships are appealing intuitively and reflect well many organizational behaviors.

A Senior Executive actor sits atop the acquisition organization model and has a Portfolio Manager reporting to it. Reporting to the Portfolio Manager are five individual PMOs (01 through 05) with different roles and capabilities within them. For example, the icon labeled "PM 02" is responsible for the technological enhancement of the initial Strike Capability. Notice the VDT representation includes a work task structure and an organization structure. The assignment links (i.e., delineated by solid lines) denote which organizational actors are responsible for the various work tasks. Finally, a dark trapezoid box is used to depict recurring meetings (e.g., coordination meetings, technical reviews, milestone reviews) that must be attended by the actors connected by links. Meetings consume actors' resources, but they also contribute toward coordination.

All of the structural elements (e.g., work tasks, requirements and interdependencies, actor capabilities, skill levels and roles, organization structure, task structure and meeting requirements) of this VDT model are developed by the authors. Such structural elements would clearly be different for each unique organization and process model. VDT also includes several dozen environmental variables with "normal" values determined empirically by prior field research. These include factors such as the level of uncertainty and noise associated with a project, the inherent propensity of an organization to make errors, and relative concern for performance quality associated with actors at different levels of organizational hierarchy. These and other environmental variables can be changed where appropriate to reflect a wide variety of different organizations and contexts. Other factors can be changed to reflect different organizational designs. For instance, the level of centralization and formalization can be varied by changing design variables. The corresponding VDT model behaviors have been developed empirically. We capitalize upon such empirically developed behaviors to design and compare new acquisition organization models and subject them to changing environments.

VDT also includes several performance variables for comparison. In addition to standard simulation measures such as project duration and cost, VDT also includes measures such as levels of rework, coordination and delay, in addition to risk measures keyed to various attributes of importance (e.g., tasks left undone, missed communications, project-level errors). Some of these performance variables are correlated often with one another, whereas others highlight tradeoffs that must be made. In other words, where a project is running behind schedule but on budget, a leader or manager can decide to employ more resources. This often has the effect of increasing the rate of progress while also increasing the rate of expenditure. Other tradeoffs such as those between cost and risk or schedule and coordination require balance in a similar fashion. It is important to note again the extensive and longitudinal validation of VDT provides considerable confidence that the organizational behaviors emulated by our computational model will reflect well those of operational organizations in the field.

Experimental Design

As is appropriate for the cumulative accretion of knowledge through research, this study builds upon prior work using VDT methods and tools to examine alternate organizational designs and environmental conditions. For instance, Kim and Burton (2002) use VDT to model projects with varying levels of task uncertainty and centralization, measuring the effects on cost, schedule and risk as dependent performance variables. They find a relationship between organizational structure and performance. And they examine project risk, measuring the likelihood that outputs from a project will not be integrated at completion, or that the integration will have defects. The study calls attention to the impact of centralized control on organizational performance in light of task uncertainty. It also suggests that managers should pay attention to such aspects of organizational structure and should consider the importance of project quality in addition to profitability alone. In another instance, Nissen and Buettner (2004) use VDT to model command and control in military missions. They model organizations having varying levels of bureaucracy, coordination and knowledge, measuring the effects on mission duration and risk as dependent, performance variables. They find a similar relationship between organizational structure and task performance and overall risk, and they suggest that organizational leaders must choose and balance the performance measures that are most relevant to the project's environment and desired outcomes.

In this study, we emulate the behaviors of three different modeled organizations which vary in degrees of hierarchy, centralization and formalization, and which are subjected to different levels of environmental stress. Briefly, our three designs of organizations have the same amount of work volume to perform, with the same level of team experience and individual skills involved. What differs among them is their degree of autonomy and empowerment, specified by several VDT constructs. Therefore, we build upon the kinds of prior research noted above, and we extend such prior research to address the acquisition domain. We also extend prior research through the greater number and variety of organizational design changes and degrees of environmental stress examined in this study.

Figure 7 reflects today's acquisition organization (labeled "Typical") with high centralization, formalization and three layers of decision hierarchy, somewhat like an ACAT II program or set of projects within the DoD.

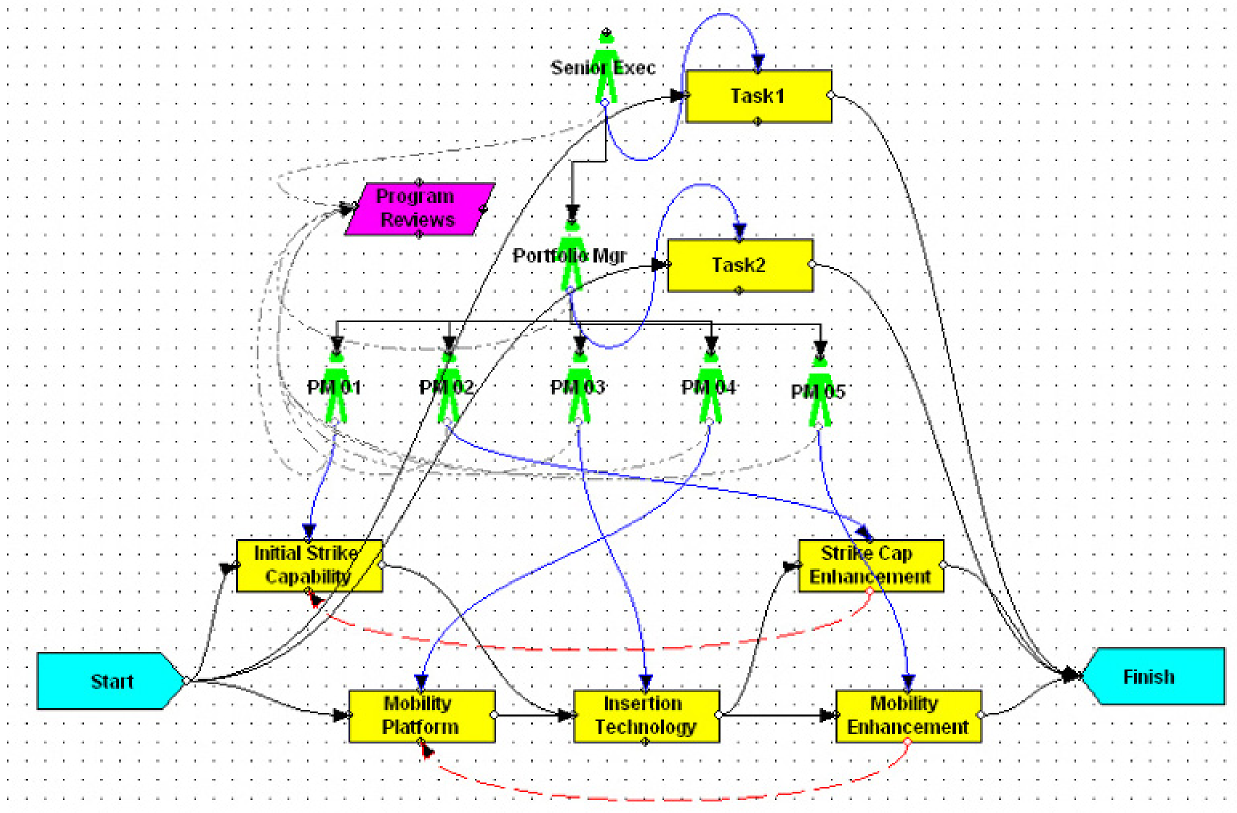

Figure 7. Typical Acquisition Organization Design and Project Work

In contrast to the typical organization, Figures 8 and 9 depict two alternate organizations with fewer layers of decision hierarchy and lower centralization and formalization. The first organization (labeled "Decentralized") has less hierarchy and control overhead in its management structure. Note the removal of the "Senior Executive" position in the representation, whose VDT role of PM has been delegated lower to the Portfolio Manager, now labeled as "Leader." As in reality, the supervision structure in the VDT model is an exception-handling hierarchy. It is the chain of command for information and decision about problems discovered in the course of a project. Positions of PM 01, 02, and others still act within the VDT simulation as Subteam Leaders who handle some exceptions and pass others up the hierarchy for resolution.

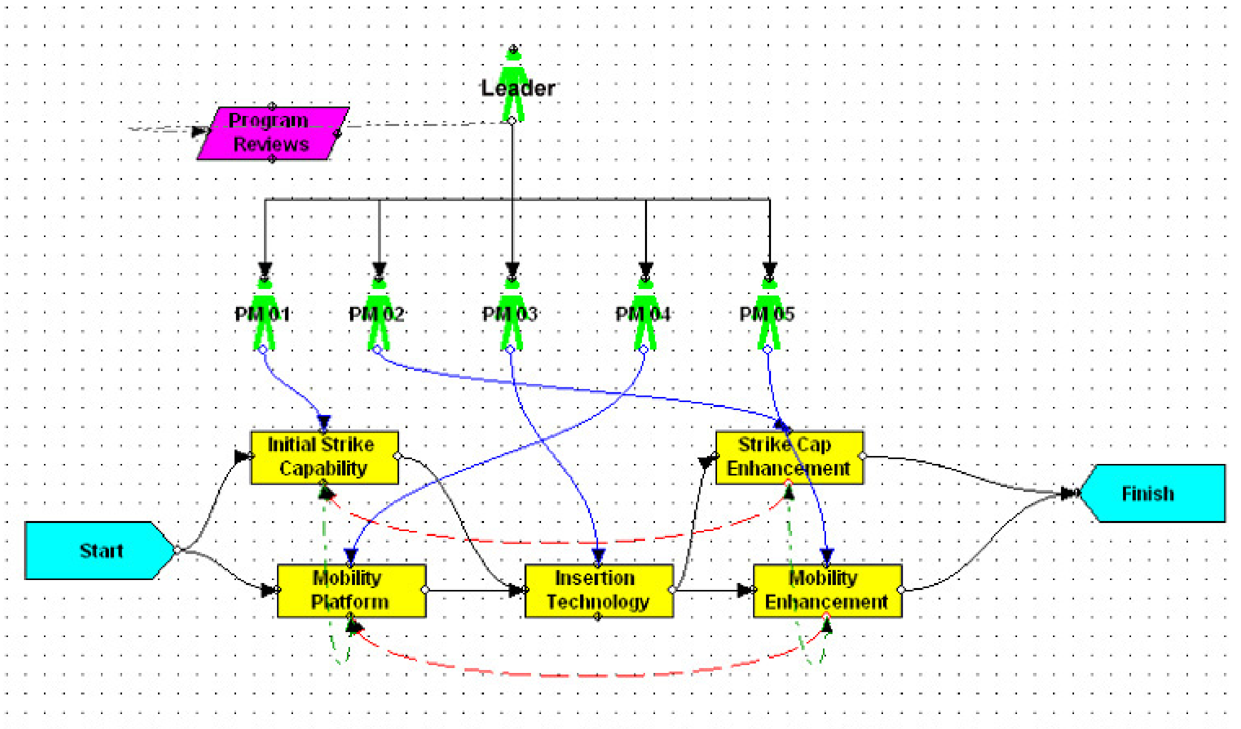

Figure 8. Decentralized Organizational Design and Project Work

The second organization, depicted in Figure 9 (labeled "Holonistic") has no overhead management structure at all. Here, each PM position in the figure remains designated a Subteam Leader within the VDT tool. The various PMs communicate with one another directly. Table 1 shows the VDT settings for organizational parameters to be tested. Additional modeling detail on organizational design parameters is found in Appendix A.

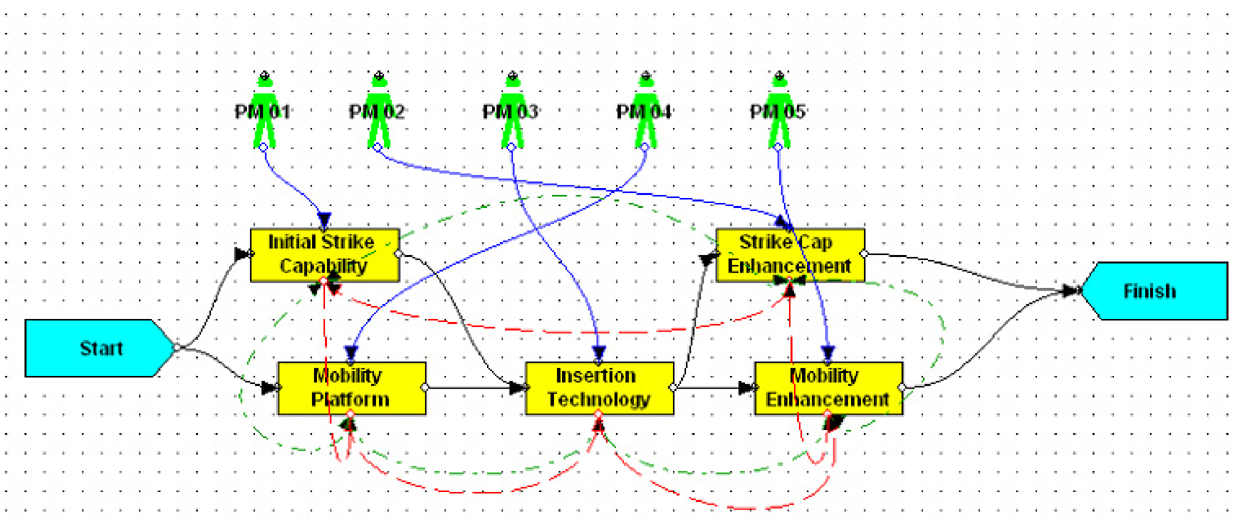

Figure 9 . Holonistic Organizational Design and Project Work

Table 1. Organizational Design Parameters

Organizational Parameter	Typical	Decentralized	Holonistic
Centralization	High	Low	Low
Formalization	High	Low	Low
Matrix Strength	Low	High	High
Hierarchy	3 layers	2 layers	1 layers
Sr-Cmd (Sr Exec PM):	1 FTE	0	0
Mid-Cmd (Port Mgr SL):	1 FTE	1	0
Operations (PMOs):	50 FTE	50	50
Communication Links	0	2	5
Info Exchange Prob	0.1	0.9	0.9
Application Exp.	Low	Medium	Medium
Meetings	More	Less	None
Functional Error Prob	0.1	0.2	0.2
Project Error Prob	0.1	0.2	0.2
Rework Links Str	30	10	10
Team Experience	Medium	Medium	Medium
Skill Level/Matched	Medium	Medium	Medium

Environmental stress is applied to our three organizational designs via the VDT constructs *requirement complexity, solution complexity,* and *task uncertainty* (appropriate to environments that project offices often face with technology maturity, interoperability requirements, etc.) as well as higher noise (distractions) and increasing functional- and project-error probabilities. For the experiment, each of these three factors is specified at two levels: routine and stressed, shown in Table 2 below. Hence, a full-factorial design consists of six trials (i.e., three alternate organizational designs x 2 different environmental conditions), which we designate according to the levels corresponding to a set of environmental factors. Additional modeling detail on environmental parameters is presented in Appendix B.

Table 2. Environmental Parameters

Environmental Parameter	Routine	Stressed
Requirement Complexity	**Medium**	**High**
Solution Complexity	**Medium**	**High**
Uncertainty	**Medium**	**High**
Noise	**0.3**	**0.4**
Functional Error Probability	**0.1 & 0.2**	**0.3 & 0.4**
Project Error Probability	**0.1 & 0.2**	**0.3 & 0.4**

We examine the dependent variables of particular interest in the acquisition domain: *cost, schedule duration* and *project risk*. We also make note of the maximum position backlog, rework volume, coordination volume, and decision wait time, as these have implications for managers to consider. Schedule is important to project managers, and time is often viewed as money because of the staff that must be paid as long as they are retained—whether productive to the project or not. Project cost is measured in $K, and pertains to staffing costs only, as no material costs are modeled in our experiment. Project risk, as mentioned above, is represented as the likelihood of an incomplete project outcome, which relates directly to project quality. While every task within a project may not be critical to project quality, more tasks incomplete or defective place the overall project at risk for failure. Where lives are at stake, such as in new pharmaceutical compounds, new passenger aircraft, or defense weapon systems involving lethality and survivability, overall project risk may be a difficult trade for managers also concerned with project cost and schedule.

EXPERIMENTAL RESULTS

In this section, we report on the results of our computational experiment. Summarized in Table 3 is each of the six trials in this full-factorial experiment. The table includes measures for project cost, schedule and risk, in addition to other metrics that can provide insight into organizational dynamics (rework volume, coordination volume and decision wait).

Table 3. Experimental Results

Measure	Typical Organization in Routine	Decentralized Organization in Routine	Holonistic Organization in Routine	Typical Organization Under Stress	Decentralized Organization Under Stress	Holonistic Organization Under Stress
Duration (dys)	556	428	407	580	604	458
Cost $K	$8,085	$4,674	$4,565	$8,561	$6,708	$4,973
Project Risk	0.41	0.54	0.76	0.37	0.55	0.76
Max Backlog (dys)	26	12	12	30	27	19
Work Volume (dys)	4800	4500	4500	4800	4500	4500
Rework Volume (dys)	124	866	465	401	2747	740
Coordination Volume (dys)	3051	423	742	3205	952	976
Decision Wait	20	54	0	67	186	0

Examining these results, we see that the baseline organization—the Typical Organization in Routine environment—completes the series of projects in 556 days, at a cost of $8,085(K), with a project risk index of 0.41. While these are the three primary success measures of any project, the VDT simulation provides more insight in terms of position backlog (e.g., one actor got 26 days behind in work at one point during the project). The tool can also identify when this occurs so that planners can split tasks or assign more resources for specific tasks. Work volume refers to the amount of effort expected to complete all project tasks under ideal conditions (e.g., no noise, errors or miscommunications). Rework Volume refers to the simulated time needed for all positions on a project to perform required rework. Coordination volume is the cumulative time positions spend during a project processing information requests from each other, attending meetings, and other coordinative tasks. Decision Wait measures the cumulative time spent by positions waiting for decisions to be made in a project. These values for our baseline case provide a basis for comparison with results for alternate organizational designs and environmental conditions.

Comparing these results with those obtained by the Decentralized and Holonistic Organizations in the Routine environment, key differences are apparent. Decentralized and holonistic organizations fare considerably better (in terms of both cost and schedule) in the routine environment than their more typical counterpart organizational design does. Program schedule or duration is reduced some 23% (from 556 to 428 days) with the Decentralized Organization and 27% (from 556 to 407 days) by changing organizational structure toward more Holonistic. Program cost is reduced similarly by 42% (from $8085 (K) to $4674 (K)) with Decentralized and 44% (from $8085 (K) to $4565 (K)) with Holonistic in the successive design iterations. However, project risk increases appreciably in both alternate organizations, going up to 54% and then to 76%, respectively, in decentralized and holonistic designs. Here, we find that Decentralized and Holonistic organizational forms offer a combination of advantages (e.g., shorter schedule duration, lower cost) and disadvantages (e.g., higher risk) with respect to the Typical acquisition organization in a routine environment.

Upon examination of these organizational designs under stress environments, we find the Typical Organization suffers cost and schedule growth in the 4-5% range (i.e., 580 days, $8561K), with a slight decline in project risk (0.37). Decentralized and Holonistic organizations under stress perform better in the cost realm with 22% ($6708K) and 42% ($4973K) reductions compared with the Typical. The Decentralized design reveals longer schedule duration (604 vs. 580 days), but the Holonistic organization shows a 21% decrease (458 vs. 580 days). Again, project risk climbs in stress environments to 55% for Decentralized and to 76% for the Holonistic.

Figure 10 illustrates graphically the dynamic relationship we find between cost and organizational design. Notice, in the routine environment, project cost decreases abruptly with a shift from a Typical to a Decentralized organizational form. But, negligible additional improvement accrues to the Holonistic design. Alternatively, in the stressed environment, the Decentralized organization performs better than the Typical does, and the Holonistic organization performs better still. Notice also how costs are higher for every organizational form in the stressed environment than they are in the routine one.

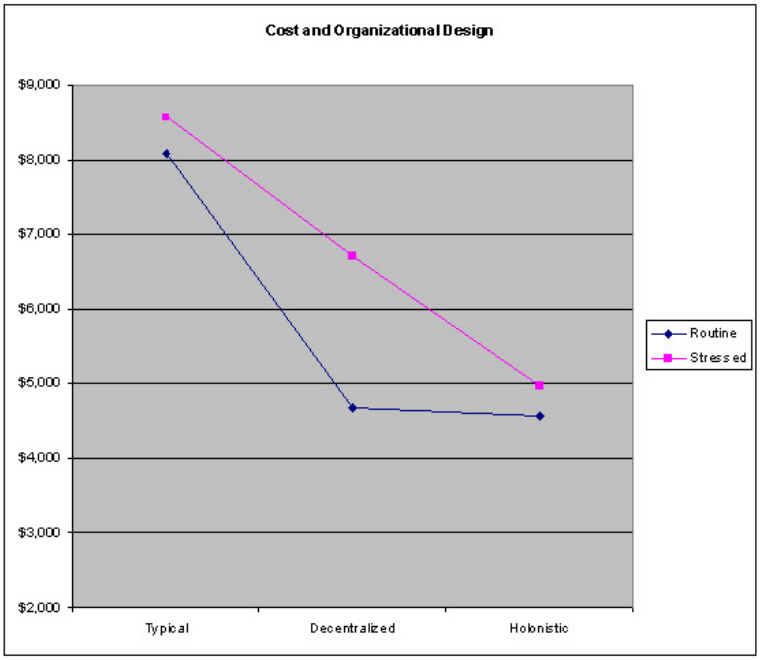

Figure 10. Relationship between Cost and Organizational Design

Figure 11 illustrates the relationship between risk and organizational design. Here, we observe a monotonic increase in risk corresponding to progression in organizational form from Typical, through Decentralized, to Holonistic. As costs decrease across these alternate organizational forms, risk increases in lock step. Unlike the cost results, however, the stressed environment appears to exert little influence in terms of risk.

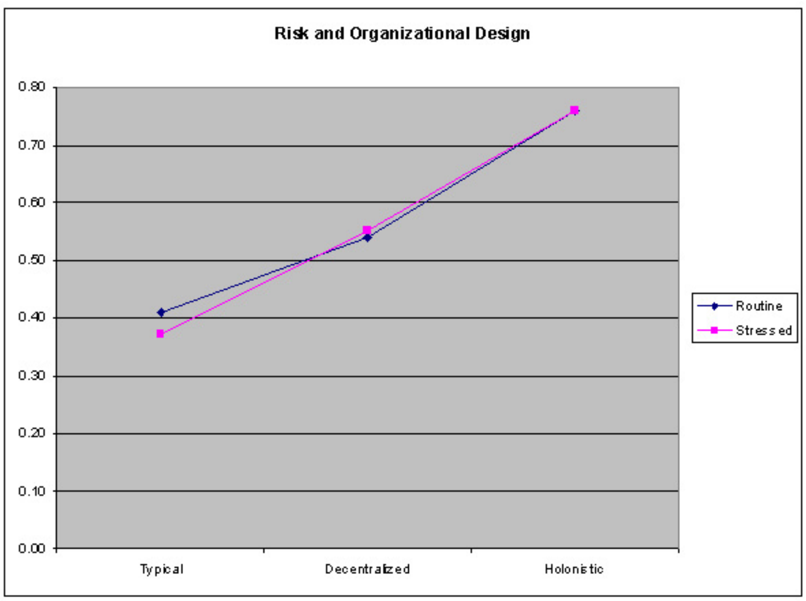

Figure 11. Relationship between Risk and Organizational Design

Interpreting these results, the researchers found that the less centralized, formalized and hierarchical organizational designs perform better in terms of cost and schedule than other designs, but with accompanying project-quality risk. Interpreting these results further, in which schedule and cost are of primary concern to all project managers, decentralized control (especially in stressed environments) may provide a more cost-effective approach. Alternatively, where project risk or quality is paramount, formalized procedures, vertical information flows, and centralized decision-making typical of bureaucratic organizational forms can be seen as superior. This reflects a fundamental tradeoff between performance measures and organizational design, as conceptualized generally in terms of Contingency Theory (Lawrence & Lorsch, 1967). And as Kim and Burton (2002) noted, the theory is actually extended by the evidence of risk coming into play with a more rapid and inexpensive project solution afforded by empowered actors with relevant information at their organizational edge.

The DoD, like sponsors of projects in the FDA's pharmaceutical arena and in the FAA's commercial aviation arena, is averse generally to risk due to the safety and survivability aspects of many of its developmental systems. Indeed, the modeling here can be viewed as confirmation of the DoD's varying levels of decision hierarchy correlating to estimated program dollar thresholds (stratification of acquisition categories I though IV) as a means of addressing cost risk. However, and just as important to illustrate, high levels of bureaucracy place considerable stress on acquisition organizations and come at their own cost. Are 40% program cost growth and 25% schedule growth commensurate with 20 – 50% program risk reduction? Might a commensurate amount of risk be alleviated through a less-expensive means? Clearly, tools such as VDT provide a new way of gaining insights into these important program considerations, particularly when forming organizations for the management of weapon system developments.

CONCLUSION

The DoD is a large, bureaucratic, rule-intensive organization that may not be suited well for its environment. Building upon prior research on acquisition centralization and knowledge dynamics, we employ computational methods to assess the behavior and performance of different organizational designs in varying environments. Our results reinforce Contingency Theory and suggest particular characteristics of different acquisition environments that make one form relatively more or less appropriate than another. Practically, answers to our research questions have direct and immediate application to acquisition leaders and policy makers. Theoretically, we generalize to broad classes of organizations and prescribe a novel set of organizational design guides.

In this study, we use the VDT modeling environment to represent and emulate the behavior of an acquisition organization. Although the Typical acquisition organization modeled in this study is representative of such organizations in practice, we do not claim to have experimented—even computationally—with an operational organization. Rather, we experiment computationally with a high-level organizational model, illustrating the method, use and utility of our approach for exposition. We then conceptualize and model two alternate acquisition organizations, manipulating key factors of their organizational designs. We subject them to two environmental contexts, routine and stressed, comparing their performance in terms of cost, schedule and risk.

In routine circumstances, our experimental decentralized and holon-type organizations out-perform typical hierarchies in measures of cost and schedule. Under high stress from task uncertainty, noise, and error probability, our decentralized and holon-type organizations completed their same project work volume as well, faster, and for less cost than their centralized counterpart. In both environments, however, our less formal organization structures yield a higher project-quality risk.

Our findings are similar to those of other VDT researchers who find the relationship between organizational performance improvements and increasing project risk from decentralization in environments of uncertainty (Kim & Burton, 2002) and worker knowledge (Nissen & Buettner, 2004). They offer an extension of contingency theory to include risk as a dependent variable for organizational structures and project outcomes. Our results reveal the same relational patterns of performance capabilities among the three organizational designs and across differing stress environments. They underscore complex interactions between organizational design factors, and suggest fundamental tension and decision tradeoffs between important performance measures such as project cost, schedule and quality/risk.

The results provide several implications for managerial practices and application of organization theory regarding the relationships between organizational structure and performance. Understanding when the bureaucracy is relatively beneficial and how this rigid organizational form can negatively influence project cost (and positively impact project risk) is important for acquisition practitioners today. The apparent implications are that adopting a decentralized structure in accordance with contingency theory may not lead to higher unit performance, since it might instead produce poorer project quality. But, we suspect it is insufficient to only assume that more bureaucracy alleviates risk with attendant costs, or that managers must simply choose either fast and cheap, or better quality results.

In the early 1990's, with a goal of shortening development times, reducing cost, and increasing numbers of scientific missions flown, NASA adopted a "Faster, Better, Cheaper" approach to project management. This management philosophy was implemented in spite of an old project management adage that project managers could have any two of these performance outcomes, but not all three (Spear, 2000). This maxim is supported somewhat by the findings of Lin and Carley (1997) regarding decision accuracy in organizations under time pressure. After the several unmanned mission failures, and ultimately the February 2003 Columbia disaster that claimed the lives of seven astronauts, an analysis of NASA failures blamed a more risk-tolerant culture as an organizational cause of the accident.

The DoD, having large complex systems with inherent risk of their own, is particularly averse to risk in its decision structure and perhaps even its organizational culture. With growing federal budget deficits and base re-alignments, it is also particularly cost-constrained. And with accelerating obsolescence rates of weapon system technology, the DoD remains under considerable pressure to reduce project schedules as well. Even with simple models, we show that project performance can be examined with various organizational designs and under differing environments. Perhaps for the first time—or at least to an extent unachievable heretofore—we show how managers can gain fundamental insights into the inherent project tradeoffs *in advance of making project decisions*. The practical significance should be apparent immediately.

These experiments support propositions that information processing is a primary organizational activity and is associated with project cost and duration (i.e. the more information processing a project requires, the more costly and lengthy the project becomes). Certainly, there is attendant benefit to the information processed as well. However, the additional measure of project-quality risk is critical for many types of projects, and its emerging relationship from these studies and our most recent work begin to shape a new hypothesis: that perhaps there is an optimal organizational design solution, relative to cost, duration *and* risk. If managers can ascertain early on the criticality (and tolerable level) of project-quality risk, they can perhaps select along a continuum the level of organizational hierarchy and centralization needed to control project outcomes. Or, reframing the question, how much will added bureaucracy cost to alleviate risk? The key point is: the answer will differ—necessarily—for every project. A one-size-fits-all acquisition policy is naïve given such knowledge and our ability to emulate organizational performance as illustrated in this article.

Building upon the VDT constructs introduced in this article, one day researchers may even develop techniques for design optimization based on project objectives (e.g., speed vs. risk) and environment. Leaders, managers and researchers may develop the capability to design organizations, work processes and technologies using computational techniques comparable to those employed for designing airplanes, bridges and computers. That day is not yet here. But, through research along these lines, we can both foresee and accelerate its arrival. Meanwhile, the centralized control that dominates current acquisition thinking and policy merits re-examination in light of this study. Such control imposes costs as well as accrues benefits. We know now how to measure and compare them: via computational experimentation.

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APPENDIX A: DESIGN OF ORGANIZATION MODELS

This appendix provides additional detail about the design of our experimental acquisition organization models. Table 1 above specifies design parameters and VDT simulation settings for all three of our organizational designs: Typical, Decentralized and Holonistic. We reproduce the information below as Table 4 and discuss the various design parameters.

Table 4. Organizational Design Parameters

Organizational Parameter	Typical	Decentralized	Holonistic
Centralization	High	Low	Low
Formalization	High	Low	Low
Matrix Strength	Low	High	High
Hierarchy	3 layers	2 layers	1 layers
Sr-Cmd (Sr Exec PM):	1 FTE	0	0
Mid-Cmd (Port Mgr SL):	1 FTE	1	0
Operations (PMOs):	50 FTE	50	50
Communication Links	0	2	5
Info Exchange Prob	0.1	0.9	0.9
Application Exp.	Low	Medium	Medium
Meetings	More	Less	None
Functional Error Prob	0.1	0.2	0.2
Project Error Prob	0.1	0.2	0.2
Rework Links Str	30	10	10
Team Experience	Medium	Medium	Medium
Skill Level/Matched	Medium	Medium	Medium

Our experiments simulate the acquisition efforts of five small project-management offices oriented on an initial strike capability (such as one provided by a missile or direct-fire weapon), integration into a mobile platform (such as a ground or air vehicle), and followed by block enhancements to both sets of capability from insertion of technology. These types of effort are common within program executive office portfolios across the military services. To simulate the completion of these projects, we design three different organizations with similar resources, but varying parameters of organizational control.

Centralization, Formalization and Matrix Strength comprise a group of variables that work together in our modeling tool to characterize levels of bureaucratic organizational control. Low Centralization settings in the Decentralized and Holonistic models mean decisions are made by the individual responsible positions. Centralization reflects decision-making in the organization—either by senior project positions or by "decentralized" individuals. With high Centralization, there is more communication required. Formalization measures how formal the communication is in an organization, with high Formalization meaning that communication tends to occur in formal meetings (despite the many informal communication occurring in any typical project office), and low settings reflecting informal communication among positions. Matrix strength characterizes the probability that workers will attend to exchanges of information—

whether via meetings, communications about tasks, or noise. It conveys “connectedness” and can correspond to geographical collocation of workers. Typical major program acquisition organizations have workers and decision makers distributed across the country, and there is a greater need for meetings. The low setting for Typical acquisition organizations, however, reflects high meeting quality and complements high Formalization. Conversely, high Matrix Strength, which complements low Formalization, characterizes our flatter, more Decentralized or Holonistic organizations. In the “Typical” model, we use a three-level management hierarchy with two different full-time equivalents (FTE) in two management positions, acting as portfolio manager and senior executive. We reduce to two, and then one in the other derivations. The PM and SL designations beside their positions are VDT designations, which connote decision-making. The 50 FTEs aside—Operations represent project management office personnel in five distinct project work areas that are interdependent, and become more strengthened with communication links, used as such by the VDT. In the Typical DoD acquisition organization, we have observed it is common for individual project offices within a PEO to communicate infrequently, though there is a great deal of vertical communication within the hierarchy, evidenced in the model with Meetings. We also reduce the number of meetings in the successively flatter organizational designs.

Correspondingly, hierarchical communication is also depicted via a low setting (0.1) of Information Exchange Probability for the Typical Organization and growing much higher (0.9) in the flatter designs. This is characteristic for a project involving mostly routine daily jobs performed by skilled workers (Typical design). A higher value is given the designs with more highly interdependent tasks that are being performed by very busy workers.A low setting of Application Experience for the Typical organization, and set at the entire program level, describes how many new R&D projects the positions may have worked on before, in spite of relative individual skill levels (which are all presumed as Medium and Matched to the work tasks assigned across all three designs). The Decentralized and Holonistic learning organizations are envisioned as learning organizations, with the benefit of some Application Experience (set at medium), from less complicated information processing and learning.

Five Rework links connect all tasks in the Holonistic design, given the lack of an overhead hierarchy as an integrative function. This is opposed to two links in the Decentralized and Typical designs. Likewise, Rework Strength designations shift to reflect success/failure dependency as higher in the Decentralized and Holonistic, and lower in the Typical hierarchy, commensurate with associated task interdependency. In much the same way, the stove-piped, independent efforts within the Typical organization hierarchy are represented in lower Functional and Project Error Probability settings. Higher settings for the flatter organizational designs convey the challenge of integration and alignment they must face without an overarching control entity.

The total simulated work task effort of all organizational designs is the same, except that layers of management in the Typical configuration have their own management tasks that run about 25% of the duration of the project’s planned timeline. The team experience value in the VDT tool affects the amount of information exchange on the project and the way a position’s information processing speed is calculated. Team Experience for the work effort is set to medium for all organizations, representing a measure of how successfully the team has performed related projects.

APPENDIX B: ENVIRONMENTAL PARAMETERS

This appendix provides additional detail about the environmental scenarios that our experimental acquisition organization models were subjected to. Table 2 above specifies environmental parameters and VDT simulation settings for both of our environmental conditions: Routine and Stressed. We reproduce the information below as Table 5 and discuss the various parameters.

Table 5. Environmental Parameters

Environmental Parameter	Routine	Stressed
Requirement Complexity	Medium	High
Solution Complexity	Medium	High
Uncertainty	Medium	High
Noise	0.3	0.4
Functional Error Probability	0.1 & 0.2	0.3 & 0.4
Project Error Probability	0.1 & 0.2	0.3 & 0.4

Requirement Complexity describes the degree of task complexity, which is relative to the total number of project requirements that the task must satisfy. Representative of current DoD acquisition environments are state-of-the-art technologies and interoperability requirements. As such, there is a common environment of at least a medium setting within our VDT tool for organizations under even routine circumstances. An even more highly optimized design could have many tasks with a high requirement complexity, and is appropriate for our "stressed" settings.

Solution Complexity represents the number of solutions to which a task contributes. The degree of complexity reflects the effect a task has on the tasks that depend on it. Thus, for routine circumstances, we use "medium" and "high" for stressed scenarios.

Uncertainty is a setting regarding the amount of communication across links needed for a task's (and its dependent tasks') completion. Task uncertainty reflects the effect that other tasks can have on each other within the project. Task Coordination volume and the number of communications increase with higher uncertainty, so we selected "medium" for routine and "high" for stressed environments.

Noise Probability describes the interruptions or distractions that detract from work on project tasks. The probability of noise is set at 0.3 for our routine scenarios and 0.4 for stressed.

Functional error probability is the probability that a task will fail and require rework. Functional errors are localized to an individual task and, thus, only cause rework in that task. Functional errors could be discovered via self-check, a project-review meeting, or a supervisory review. Depending on the level of centralization and hierarchy in the project, an exception can be handled by the responsible position or someone up the hierarchy. When a functional error is detected, an exception is sent to the responsible position or to a supervisor, generating either rework of the task, a quick fix, or feigned ignorance of the problem. Project error probability is the probability that a task will fail and generate rework for all dependent tasks connected to it by rework links. The more rework links there are in a project, the more rework is generated by the exceptions that occur. We select 0.1 as our routine setting for the Typical organization and 0.2 for our Decentralized and Holonistic designs, reflecting their decreasing management potential for intervention. For stressed scenarios, we use 0.3 for our Typical organization and 0.4 for our Decentralized and Holonistic designs.

From Market to Clan: How Organizational Control Affects Trust In Defense Acquisition

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ABSTRACT

Military acquisition relies upon industry for new product development, but market organizational control is not recommended for knowledge-intensive work. Unfortunately, increasing hierarchy-control mechanisms, such as formalization, could reduce trust. What is the appropriate balance of control mechanisms and trust for an IPT in the DoD acquisition realm? We conducted interviews and surveys in a major military acquisition program office employing IPTs, Alpha Contracting and collocation. We found that the relationship between formalization and trust was different between government and contractor team members. Acquisition managers must understand the relationships between control mechanisms and trust within and between organizations to increase collaboration between government and contract personnel.

Key words: Trust, Organizational control, Transaction-cost Economics

INTRODUCTION

The government and industry partnership is central in the military acquisition domain—with both parties pursuing both common and separate goals based upon their buyer and seller roles. Organizational control theory holds that in such environments of differing goals, managers can use three types of control systems: the market, the bureaucratic, and the clan (Ouchi, 1980). In *market organizational control systems,* managers contract with and then monitor their suppliers. In *bureaucratic (hierarchical) organizational control systems,* formal control mechanisms (such as rules and regulations) are enforced through hierarchies. Workers within *clan organizational control systems* self-manage using common values, traditions and beliefs. Acquisition of new weapon systems has traditionally employed the *market* form of organizational control with the industry side of the partnership, and *bureaucratic* organizational control within the Department of Defense (DoD).

Given the nature of new product development, DoD Program Management Offices typically operate in the context of relatively high asset specificity, risk aversion and uncertainty. Although these variables have been shown by research to encourage the switchover from *market* to *hierarchy* control, the government/industry buyer/seller relationship precludes the adoption of hierarchical organizational control or even quasi-vertical integration.

However, over the last 10 years, defense acquisition has adopted Integrated Product and Process Development (IPPD), using Integrated Product Teams (IPT) to encourage government and contractor personnel to work more closely together to design and build new products (OUSD, 1998). IPTs, Alpha Contracting, management councils and other organization-oriented changes (such as collocation of government and contractor personnel) have extended the *market* form of organizational control; yet, each of these must stop short of switching over to the *hierarchical* or *bureaucratic* organizational control form given the separation of public and private enterprise.

The government's goal orientation in its procurement pursuits is provided in the guiding principles of FAR Part 1.102:

The Federal Acquisition System will—(1) Satisfy the customer in terms of cost, quality, and timeliness of the delivered product or service by, for example—(i) Maximizing the use of commercial products and services; (ii) Using contractors who have a track record of successful past performance or who demonstrate a current superior ability to perform; and (iii) Promoting competition; (2) Minimize administrative operating costs; (3) Conduct business with integrity, fairness, and openness; and (4) Fulfill public policy objectives. (FAR, 2004)

In short, the government seeks the best possible value of goods and services for the least cost to the taxpayer, while industry seeks to maximize profit while avoiding competition. Fundamental goal differences notwithstanding, this partnership has historically yielded unmatched military capability, as well as profit for shareholders.

Trust has also been recognized as a critical ingredient in modern defense acquisition (Siemsen, 2002). Although *trust* is considered to be the basis of the *clan* form of organizational control, scholars recently have observed that *trust* can be used to extend *market* control and to avoid switching over to *hierarchical* control.

This research study asks: What is the appropriate balance of hierarchy-control mechanisms and trust for an IPT in the DoD acquisition realm*?*

In this paper we describe the changes in work structure in major military acquisition programs employing the IPPD and Alpha Contracting approaches. We analyze the risks for client and supplier representatives in new product development teamwork and develop hypotheses about the effect of control mechanisms—such as formalization—on interpersonal trust. We conducted eighteen interviews and a survey in a major weapon system program office employing IPTs, Alpha Contracting and collocation to test our hypotheses. We analyze and report the results and describe the implications for managers of IPTs.

THE EVOLVING GOVERNMENT/INDUSTRY RELATIONSHIP

New product development is increasingly undertaken in the context of inter-firm collaboration, in which a client firm engages an outside supplier to design and/or engineer a component, subsystem or process (Carson, Madhok, Vasrman & John, 2003). Likewise, in defense acquisition the government engages industry suppliers with contracts to develop their new products. Because the US government is often the sole purchaser of newly developed weapon systems, something of a monopsony exists in which the supplier cannot sell the product to another purchaser without the government's consent. Similarly, once the government selects a single supplier to develop a new technology, the supplier gains a competitive advantage over other suppliers, creating a monopoly supply situation for follow-on procurement contracts. Therefore, the power of buyer and seller are somewhat balanced in a situation in which asset specificity develops and partners change to entail extremely high transaction costs. In such a situation, exit costs are high for both parties: the cost to the government of nonperformance by the contractor is high, and the cost to the contractor of finding another partner is very high as well.

Alpha Contracting

The government's traditional contracting approach (before acquisition reforms of the last decade) required successive iterations between the client and the supplier—to discover the client's requirements and the applicable supplier technologies—until a relatively complete contract could be written. This traditional sequential interdependency relationship has changed to a closer reciprocal interdependency relationship with Alpha Contracting, in which the client and supplier work together to define the requirements and discover solutions. Again, the Federal Acquisition Regulation gives guidelines for this dialogue:

> The Government must not hesitate to communicate with the commercial sector as early as possible in the acquisition cycle to help the Government determine the capabilities available in the commercial marketplace. The Government will maximize its use of commercial products and services in meeting Government requirements. (FAR Part 1.102-2)

Alpha Contracting has evolved from a 1990s-era reform initiative aimed at improving government and contractor communications in order to increase efficiency and effectiveness. At its very foundation is a need for increased trust and teaming toward common government/industry objectives, within the paradigm of their buyer/seller relationship. By encouraging more collaboration early in the contracting negotiations phase, Alpha Contracting reduces procurement costs and cycle time via joint and concurrent processes and information flows. Key activities in the process are: specification of requirements, preparation of the statement of work, negotiations and executive review. Even though direct savings may be hard to quantify, most agree the savings derived from Alpha Contracting are substantial, even if the only savings counted is the increase in the program office staff's time free to solve other problems (Nissen, 1997). As Siemsen (2002) explained, the indirect benefits extend to both government and contractor as monitoring costs of other agencies like Defense Contract Audit Agency (DCAA) and Defense Contract Management Agency (DCMA) are precluded. This initiative actually seeks and obtains the information that enables a trust-based partnership. The shift from sequential to concurrent requirements definition and design is happening in many industries, not only the DoD. For example, the construction industry has adopted the design/build approach.

In addition to collaborating on the requirements definition and contracting phase of new product development, the interpersonal closeness developed in the Alpha Contracting approach can be carried over to the development stage. The use of Integrated Product Teams (IPT) encourages the government's user representatives and the contracting supplier's engineers to work together as the new product is designed and the initial prototypes are built. In some instances, the government's representatives and the contractor's engineers are collocated in the same building. The potential advantages of this increasingly close interdependency between client and supplier are to shorten the design process, reduce development costs and, hopefully, to increase the quality of the resulting product. These advantages mainly apply to the government, but the advantage to the contractor in such closer interaction might be a perceived increase in the likelihood of winning a future competitive bid. The potential disadvantages of this trend towards more concurrent engineering include the difficulties of achieving higher interdependencies between everyone involved in the project, including the government representatives and the contractor's engineers, designers and developers.

ORGANIZATIONAL CONTROL MECHANISMS: MARKET, HIERARCHY AND CLAN

Transaction-cost economics proposes that when the specific identity of the parties has an important cost-bearing significance, the transaction becomes idiosyncratic, rather than unspecialized (Williamson, 1979). Cost economies in production occur if the supplier develops a special-purpose plant or the labor force develops special-purpose skills in the course of contract execution. Special-purpose skills, which can reduce transaction costs, include institutional and personal trust.

Although both buyer and supplier have long-term interests in implementing changes through a strategy of joint-profit maximizing (meaning value to each partner), each also has an interest in appropriating as much of the gain as possible (Williamson, 1979). Productivity benefits can result in excessive haggling, which could dissipate the benefit of the changes to both parties. Alternatively, those changes could go unrealized for fear of initiating an expensive conflict. The government buyer has to trust the contractor supplier will take advantage of all potential productivity-improvement opportunities. The contractor supplier has to trust the government client will share the benefits from productivity improvements fairly.

Ouchi proposes three fundamentally different forms of organizational control for dealing with the problem of obtaining cooperation among individuals or collectives—like government buyers and contracting suppliers—who share only partially congruent objectives. These are market organizational control, hierarchy organizational control and clan organizational control (1979).

Market Organizational Control and Price

Market organizational control is based upon price (Adler, 2001), which can be a very efficient control mechanism, but the conditions for an efficient market do not always exist. In new product development, exactly how long it will take to develop a new technology or how much it will cost is difficult to predict; these unknowns make writing a fixed-price contract impractical. In the uncertain conditions provided within research and development (R&D), the government has adopted the practice of awarding cost-reimbursable contracts. This means that suppliers won't compete on price alone, but on more intangible aspects, such as their demonstrated skills, abilities and facilities; this increased range of competition reduces the strength of the market form of organizational control. In new product development, the client wants the supplier to develop extensive knowledge about the technology and users—making market-organizational control less attractive. Notwithstanding the U.S. government's sovereign right to terminate contracts for cause or convenience, the government's ability to wield market organizational control can become limited over time by the difficulty of exiting the relationship to buy from another supplier due to the asset specificity the new supplier has developed. Switching suppliers will incur huge costs and considerable time due to getting a new supplier "up to speed" on the new technology.

Hierarchy Control and Authority

When asset specificity and governance costs are high, hierarchical organizational control, based upon the exercise of authority (Adler, 2001), has advantages over market control (Chiles & McMakin, 1996). Hierarchical organizational control involves control mechanisms largely based upon formalization, which is establishing rules and monitoring behavior to ensure compliance with the rules. Unfortunately, formalization has a large administrative overhead in writing and enforcing rules. Also, in new product development, writing rules that cover all conditions when the transformation process is unknown is difficult; likewise, in knowledge work such as R&D, monitoring adherence to rules is difficult.

Clan Organizational Control and Trust

Ouchi suggests people must be able to either trust each other (i.e. have congruent goals) or to monitor performance (1979). Since monitoring performance is difficult in new product development, the situation calls for the clan form of control, which is based upon trust (Adler, 2001). Clan control relies on a "deep level of common agreement between members on what constitutes proper behavior, and it requires a high level of commitment on the part of each individual to those socially prescribed behaviors" (Ouchi, 1979). IPTs, Alpha Contracting and collocation can be seen as a move away from market and hierarchical control in the direction of clan form of organizational control. In order for clan control to be effective, the organization must have or develop an appropriate organizational culture involving higher levels of trust. Unfortunately, many managerial strategies fail due to incompatibility with the organizational culture (Schneider, 2000).

PRICE, AUTHORITY AND TRUST IN NEW PRODUCT DEVELOPMENT

Military acquisition of new products involves all three organizational control systems described by Ouchi (1979). The formal relationship between the government and the contractor is a market-based control mechanism using contracts and market power. Once the contractual relationship is established, an IPT organization is set up and the government implements formal control mechanisms. When the work starts, informal social mechanisms develop. Through the life of the project, at different levels of organization (from the top level of contact between the government and contractor, through the IPT structure to the individual team members), the three forms of organizational control operate in various combinations (Ouchi, 1979).

Several studies have looked at the conditions under which each control mechanism will be used. Some researchers propose that most organizations use some combination of all three control mechanisms of price, authority and trust (Bradach & Eccles, 1989; Adler, 2001). Adler proposes that, particularly for knowledge-based assets which form the basis for new product development, price and authority are relatively ineffective control mechanisms compared to trust.

Gunnarson and Levitt propose that when the reduction in production savings achieved through economies of scale in outsourcing is less than the increases in transaction costs due to asset specificity, the firm will switchover from market to hierarchy control (1982). New product development has two out of three of the sources of asset specificity found in idiosyncratic transactions, including technology specificity and knowledge specificity, but not typically location specificity. With high asset specificity and low economies of scale, the product development organization is likely to switchover from a market to hierarchy form of organizational control. Zaheer and Venkatraman (1995) found that asset specificity is positively and significantly related to greater degrees of quasi-integration. This means that new product development is more likely to be vertically integrated than other activities.

The US military predominately out-sources its research and development of new weapon systems; thus, it does not have complete hierarchical control over its selected industry providers. Zaheer and Venkatraman (1995) found that trust was positively and significantly related to greater degrees of quasi-integration. This means that the closer the organization was to a hierarchy, the more trust developed. But Chiles and McMackin propose that when there are higher levels of trust, the switchover from market to hierarchy will occur later (1996). Therefore, the effects of trust can be to extend the range of market control and delay the switchover from market to hierarchy.

This study asks: when the client organization extends the range of the market form of organizational control in new product development, what effect will this have on interpersonal trust between IPT members?

Trust in New Product Development

In this research, trust is defined as the trustor's willingness to accept the risk of relying on a trustee, even when the trustor is unable to monitor or control the trustee (Rousseau, Sitkin, Burt & Camerer, 1998; see also Mayer, Davis & Schoorman, 1995). In the trust equation (Hardin, 2000), “Person A trusts Person B about X,” which is the object of trust. Zolin and Hinds (2004) extended the equation to say “when Z,” where Z is the context of trust.

Trust is considered to be essential to cooperation (Kollock, 1994) and expected to have an impact on performance (Dirks, 1999), particularly in knowledge-intensive work (Lane, 1998) such as new product development.

Trust is highly influenced by the perceived trustworthiness of the trustee, the context (Rousseau, Sitkin & Camerer, 1998; McEvily, Perrrone & Zaheer, 2003, Zolin, Hinds, Fruchter & Levitt, 2004) and the history of the relationship. Perceived trustworthiness is the trustor’s assessment of the trustee. This multidimensional construct is proposed to contain the dimensions of ability, benevolence and integrity. Ability reflects the trustee’s skills and resources required for the necessary performance. Benevolence represents the extent that two parties share the same objectives; the trustor can trust the trustee to make decisions and act as the trustor would in the situation. Hardin calls this “encapsulated interests” (1998). Integrity is the trustee’s honesty in not misrepresenting the situation.

There are many dynamics involving risk (vulnerability) and trust from the organizational to the interpersonal levels within the Program Management Office in the IPT structure. As mentioned before, the two parent organizations may have different economic objectives, but they agree to work together to achieve the project goals of designing and developing the desired product within time, cost and quality constraints.

Individual team members also have different objectives depending upon their role in the design process. For example, a design engineer could have different (and sometimes conflicting) objectives from the government’s user representative. In the ITP, the government personnel represent the user and have extensive knowledge of how the product will be used in the field or what the logistical or maintenance issues will be. The government representative’s function is to give the contractor engineer advice on how to design the component to maximize the value to the user. The engineer’s job is to solve the engineering problems involved in the design of a new component or in integration of the new component into the system. To do so, the engineer has to understand the many constraints imposed by the function of the component and its interaction with other components in the system. The government representative’s suggestions could remove some constraints, making the component easier to design. Or he/she could add new requirements, making the component more difficult to design. The engineer has to trust the government representative in order to accept the advice. If the government representative is wrong, the contractor’s engineer could have to do a lot of additional work redesigning or reintegrating the component. Therefore, the engineer must trust that the government’s representative knows the user’s requirements (ability), has concern for the engineer’s work, won’t change the requirements without good reason (benevolence) and will be honest about what happens (integrity). Similarly, the government representative has to trust the engineer to listen to the advice, to accept or reject the advice based upon a sound knowledge of the constraints (ability), to not take the easy way out to reduce work (benevolence) and to be honest about the situation (integrity).

Risk, Trust and Control Mechanisms

Trust is only relevant when there is risk in the relationship. In addition to the usual risks of collaborative work—such as the free rider problem, in which an individual shirks his or her duties knowing that others in the group will perform them (Hardin, 1971)—new product development entails additional uncertainty regarding the ability of the design engineers to develop the new product to the client's specifications within the scheduled time and budget.

Trust and control mechanisms are strategies for dealing with the freedom of the other party to take actions that may disadvantage the trustor. Because the trustee has freedom to act, the trustor wants to reduce the amount of risk he/she is exposed to. While a trustor may use control mechanisms, such as formalization of contracts, to limit the size of risk or the likelihood or failure by the trustee, ultimately collaboration requires some risk and, consequently, requires some trust.

Das and Teng propose that trust and control mechanisms work as supplements, rather than alternatives, to create cooperation and reduce opportunistic behavior in inter-firm alliances (1998). Leifer & Mills define control as a "regulatory process by which the elements of a system are made more predictive through the establishment of standards in the pursuit of some desired objective or state" (1996, p. 117). Das and Teng also use the concept of control mechanisms, which are organizational arrangements designed to determine and influence what organization members will do. If trust and control mechanisms are supplementary, they will have a positive relationship, such that the more control mechanisms there are, the more trust will develop.

Alternatively, some theorists propose that trust and control are complimentary. In other words: the more trust there is, the less control mechanisms are needed, or the more control mechanisms are used, the less trust develops. Sitkin and Roth propose that legalistic remedies—i.e., "mechanisms that are institutionalized, mimic legal forms, and exceed legal regulatory requirements" (1993, p. 367)—will fail to restore trust and could lead to an "inflationary spiral" of increasingly formalized relations. They distinguish between trust based upon ability and distrust based upon generalized value incongruence. They propose that legalistic mechanisms are more effective in addressing reliability issues than value incongruence. Researchers have found that highly formalized management-control systems lead to escalating distrust when they are mismatched to the task at hand, such as the use of precise and deterministic measurement and monitoring in conditions characterized by high levels of uncertainty (Sitkin & Stickle, 1996).

Organizational boundaries could influence the relationship between trust and control. Dyads operating within the same organization could have a supplementary relationship between trust and control because controls provide protection and reduce the risk needed for trust. In contrast, when dyads operate across organizational boundaries, there could be more value incongruence. We propose that dyads operating across organizational boundaries will have a negative relationship between trust and control mechanisms, while those operating within the same organization will have a positive relationship.

Hypothesis 1: When the trustor and trustee belong to the same organization, there will be a positive relationship between control mechanisms such as formalization and trust.

Hypothesis 2: When the trustor and trustee belong to different organizations, there will be a negative relationship between control mechanisms such as formalization and trust.

METHODOLOGY

This research project studied a target population composed of all twenty-eight IPT teams in an Acquisition Category (ACAT) 1D major defense acquisition development program. Those IPT teams contained 368 members consisting of government, civilian, military and contractor employees. The research consisted of two elements: qualitative interviews and a quantitative survey.

Eighteen semi-structured interviews were conducted onsite with 12 government personnel and 6 contractor personnel. Interviews were voluntary and individuals self-selected to be interviewed. The growing size of the project IPT was mentioned by the Project Manager prior to the study as a potential problem. Questions were asked about collocation, team size and Alpha Contracting, but respondents were also encouraged to raise their own issues and discuss what problems and solutions they perceived.

Team members were asked to complete an online survey. A non-probability convenience sampling method was used. Team members were invited to respond on a voluntary basis.

Respondents were asked to answer questions about their demographics as well as questions about their relationship with the trustee. The respondents were asked to provide information on their work relationship with four other employees chosen at random. This design created pairs of trustor (respondent)/trustee called "directional dyads." The directional dyad is the unit of analysis. The sample size was 370 directional dyads.

Except for questions about the frequency of communication, all variables were measured using a 7-point Likert scale from "Strongly disagree" (1 point) to "Strongly agree" (7 points). Where a question was reversed in the meaning from the overall direction of other questions, the result for that question was reversed (i.e., a 1 was converted to a 7).

Trust ($\alpha = .72$) and perceived trustworthiness ($\alpha = .96$) were measured using scales developed by Mayer and Davis (1999). Zolin, Fruchter, Hinds and Leavitt (2004) proposed the questions for risk and reward, and a scale for perceived follow-through ($\alpha = .88$). Formalism ($\alpha = .80$) was measured on a scale developed by Hanks and Chandler (1995). Project communication, coordination communication and personal communication were measured by the number of times the topic was discussed per week.

Analysis

For the 370 directional dyads, t-tests for differences in means for government versus contractor personnel were conducted. To test for interrelationships between the variables, we computed Pearson correlation coefficients with respective p-values. Linear regression was used to model the relationship between the trust as the dependent variable and the various independent variables.

QUALITATIVE RESULTS

Collocation, Alpha Contracting and Team Size

Most individuals interviewed reported being collocated with their team members. The general consensus was that collocation was better, making communication easier. The positive attitude towards collocation was shared by both government and contractor personnel, but the government personnel appeared to appreciate collocation more. Government personnel reported that before collocation they had to make formal appointments to meet with contractors, journey from one building to the other (several miles) and waste the trip if the other party became unavailable. Collocation provided the opportunity to meet informally.

The few individuals whose teams were divided between two buildings reported that geographic distribution made communication difficult and slowed the process. Sometimes, although the team was collocated, the respondent had to work with other teams that were geographically distant, which caused problems. For example, a contract team member reported that difficulties arose from not being close to the Configuration Management team. Geographic separation was reported to increase "stove piping," although even those who were collocated reported this issue.

Alpha Contracting was positively received, although some contractor personnel were not familiar with the term. Alpha Contracting was mainly associated with collocation of government and contractor personnel.

Although several respondents mentioned they had never worked in such a large project team, the overall size of the project was not mentioned as a problem. A problem which was mentioned more than once was the ineffectiveness of large meetings (described as consisting of 30 to 80-plus people). The difficulty of making decisions in such a large meeting was mentioned by four government personnel.

Another problem related to team size was the difficulty created by team growth. The addition of new team members was reported to slow things down because each addition had to be briefed on what was happening.

Problems and solutions

The onsite interviews had a higher response rate from government (11) than contractor (6) personnel. As would be expected, the individuals who volunteered to be interviewed had strong opinions (usually negative) about the project. Only one respondent mentioned no problems. Respondents mentioned many of the problems that IPTs and Alpha Contracting are designed to overcome, including lack of communication, stove piping, and lack of integration. Problems mentioned included:

1. Stove piping, conflict, personalities, career-agenda people
2. Disrespect for top management
3. Lack of communication, coordination, cooperation
4. Schedule-driven, overly ambitious schedule
5. Micro-management
6. Lack of integration
7. Lack of discipline, lack of control and lack of strong leadership
8. Large meetings
9. Lack of training

Complaints were more often directed toward the system than individuals. Government and contractor personnel were just as likely to criticize their own organization's performance as that of the other organization. Despite this, there was a general feeling of frustration by government personnel who felt they had no control and no way to make the contractors heed their advice, despite sometimes feeling like they had superior training and experience to that of the contractors. Some contractor personnel also felt the government should take more control of the situation and give more direction.

Many respondents complained about the IPT team structure. There appeared to be two groups: those who preferred the “traditional” structure in which the “government told the contractors what to do” and those who preferred the IPT approach, but thought it wasn’t being followed. The Traditionalists were the larger group and represented both government and contractor personnel. Typical complaints by the Traditionalists were lack of discipline, lack of control and lack of strong leadership. Typical complaints by the IPT supporters were lack of adequate training. One government IPT supporter said:

> There is no such thing as a Government IPT. The Government IPT was created by those who refuse to break with tradition. Folks in a Government IPT do their own thing and then talk to the contractor when they’ve made up their minds. In a real IPT, the government is a representative, not a lead. -Government representative

The difficulty of integration was mentioned by both government and contractor personnel. Integration includes the need for coordination of design changes across the IPT. One Contractor mentioned, “people don’t want to make changes, it takes more work.”

Many of the individuals who volunteered for interviews belong to IPTs that have to integrate across the existing IPT structure; for example, some teams were described as Interface IPTs creating components (such as cabling) to connect system parts. If a part changes, the cables connecting to it have to change. Besides being made to work extra if a part changes, these individuals are not always told when something upstream changes. Two IPTs were created by the government to represent the two prototypes under construction and to integrate across the functional IPTS; yet, these two government IPTs weren’t reflected in the contractor structure at the time of the interviews.

QUANTITATIVE RESULTS

The descriptive statistics are reported in Table 1, which shows the means, standard deviations and F-statistic for the comparison of government and contractor personnel (See Table 1). Both government and contractor trustors had high levels of trust, between which there was no significant difference (F-statistic = 2.19, n.s.). When we distinguish dyads by both trustor and trustee (e.g., government trustor and government trustee—G to G), the dyad type with the highest trust was government to contractor. The lowest was contractor to government.

Government trustors reported significantly higher levels of project communication (F-statistic = 13.87, $P < .001$), coordination communication (F-statistic = 7.40, $P < .01$), and perceived follow-through (F-statistic = 6.46, $p < .05$) than contractors.

Table 1. Descriptive Statistics

Variable	All Mean	All Std. Dev.	Government Mean	Government Std. Dev.	Contractor Mean	Contractor Std. Dev.	F-statistic	Gov to Gov Mean	Gov to Con Mean	Con to Con Mean	Con to Gov Mean
1. Trust	4.97	1.36	5.21	1.34	4.92	1.35	2.19	5.2	5.3	5.0	4.6
2. Trust propensity	3.81	0.80	3.71	0.52	3.84	.84	1.51	3.6	3.9	3.8	3.9
3. Formalization	4.26	1.07	4.70	0.87	4.15	1.07	15.39***	4.6	4.8	4.0	4.7
4. Risk	3.96	1.17	3.79	1.08	3.99	1.17	1.51	3.9	3.6	3.9	4.3
5. Reward	5.77	1.04	5.38	0.93	5.86	1.04	11.72***	5.3	5.5	5.8	5.9
6. Project comms.	4.39	5.62	6.85	8.37	3.76	4.44	13.87***	7.8	5.2	4.1	2.1
7. Coordination comms.	3.11	4.10	4.46	4.92	2.68	3.72	7.40**	5.2	3.2	2.8	2.0
8. Personal comms.	2.27	2.58	2.81	2.79	2.11	2.52	2.69	3.4	1.6	2.2	1.6
9. Hours F2F	4.50	6.74	5.38	5.79	4.32	6.97	1.37	5.5	5.2	4.8	2.6
10. Perceived trustworthiness	5.60	1.17	5.77	1.05	5.57	1.19	1.56	5.7	5.9	5.6	5.3
11. Perceived follow-through	5.43	1.29	5.81	1.18	5.35	1.30	6.46*	5.9	5.7	5.4	5.2

*** p<.001, ** p<.01, * p<.05, + p<.10

Correlations between variables are reported in Table 2. Trust was significantly related to formalization (r = .14, p< .05) and personal communications (r= .17, p< .05), but there was no significant relationship to risk (r=-.08, n.s.) or reward (r= -.04, n.s.).

Table 2. Correlations

	1	2	3	4	5	6	7	8	9
1. Trust									
2. Formalization	.14*								
3. Risk	-.08	-.23***							
4. Reward	-.04	.12*	.18***						
5. Project comms.	.18**	-.05	.05	-.09					
6. Coordination comms.	.14*	.02	-.05	.01	.75***				
7. Personal comms.	.17*	.00	.01	-.18	.64***	.56***			
8. Hours F2F	.24***	.00	.03	-.16**	.42***	.31***	.44***		
9. Perceived trustworthiness	.80***	.13*	-.06	-.04	.12+	.07	.17*	.24***	
10. Perceived follow-through	.60***	.05	.05	-.06	.17**	.08	.22**	.30***	.68***

*** p<.001, ** p<.01, * p<.05, + p<.10

Hypothesis 1 proposed that when the trustor and trustee belong to the same organization there will be a positive relationship between trust and formalization. Both government and contractor trustors had high levels of trust, between which there was no significant difference (F-statistic = 2.19, n.s.) (See Table 1). When we distinguish dyads by both trustor and trustee (e.g., government trustor and government trustee—G to G), the dyads with the highest trust were government to contractor (M = 5.3) and government to government (M = 5.2). The lowest was contractor to government (4.6). Government trustors reported significantly higher levels of formalization (F-statistic = 15.39, $p < .001$) than contractor trustors.

To test the hypothesis, we conducted regression models for each of the different dyad types (see Table 3). In model 2, there was a significant positive relationship between formalization and trust among government trustors and government trustees ($\beta = .31$, $p < .05$). Yet, no significant relationship existed for contractor-to-contractor dyads ($\beta = -.06$, n.s.). This data provides partial support for hypothesis 1.

Hypothesis 2 proposed that in dyads when trustor and trustee belong to the different organizations there will be a negative relationship between trust and formalization. In model 2, there was a negative relationship between formalization and trust in government-to-contractor dyads ($\beta = -1.02$, $p < .01$) and a barely significant negative relationship for contractor–to-government dyads ($\beta = -.36$, $p < .10$). This data supports hypothesis 2.

Table 3. Comparison of OLS Estimates (Standardized beta Values) of Trust

	Gov to Gov		Gov to Con		Con to Con		Con to Gov	
	M1	M2	M1	M2	M1	M2	M1	M2.
Intercept	+		***		***			
Formalization	.44*	.31*	-1.02**	-.69	.05	-.06	-.13	-.36+
Risk	-.61*	-.08	.45+	.46	-.02	-.29***	-.36	-.57*
Reward	.14	-.06	.17	.14	.02	.32***	.52+	.07
Project communication	-.14	-.01	.14	-.06	.11	-.00	.11	.83+
Coordination communication	-.56	-.15	.19	.23	.00	.06	.05	-.36
Personal communication	.87**	.38*	.20	.20	.07	-.04	.41	-.47
Perceived trustworthiness		.71***		.35		.56***		.72**
Perceived follow-through		.04		.70		.35***		.40+
Adj. R-squared	.37	.71	0.71	0.71	-.02	.63	-.09	0.73
Model F	3.60*	13.11***	5.82*	4.44	0.65	22.78***	0.77	6.73**
Degrees of freedom	6, 21	8, 19	6, 6	8, 3	6, 109	8, 93	6, 11	8, 9

*** $p < .001$, ** $p < .01$, * $p < .05$, + $p < .10$ (C = Contractor, G = Government)

DISCUSSION

Our results support our theories, which propose there is a positive relationship between trust and formalization in dyads within organizations, but a negative relationship between trust and formalization in dyads that span organizational boundaries.

Likewise, market control mechanisms operating at the firm level may be ineffective in regulating behavior at the interpersonal level.

In our qualitative results, both the government and contractors asked for more controls, although the level of formalization in both organizations was moderate, with government personnel rating formalization slightly higher than the contractors (Government 4.7 and Contractor 4.15 out of 7).

In our quantitative results, formalization increased trust for government trustors, but was not significant for contractors. In contrast, contractors' trust was associated with lower risks and higher rewards. These differences between government and contractor organizations could indicate differences in organizational context or organizational culture. More research is needed to determine the source of this difference.

The relationships between trust and formalization that applied within the government and contractor organizations did not apply across organizational boundaries. Although formalization increased trust of Government trustors for government trustees, formalization was negatively related to trust when the trustee was a contractor. Similarly, although trust was not significant for contractors within their organization, contractor trustors also had a negative relationship between formalization and trust when the trustee was a government representative. This confirms that there is a negative relationship between formalization and trust when the dyad spans organizational boundaries.

Given the market relationship between the government and contracting organizations, it is possible that their formal rules only applied within each organization, and that there were few, if any, rules that applied across organizations. For example, the government's rules applied to government personnel; yet, those same rules might not apply to the contractor's personnel. Similarly, the contractor's rules may not apply to government personnel.

When the organizational control is a market relationship at the organizational level; highly interdependent work seems to be difficult at the interpersonal level. In this context, we found individuals experienced difficulties which they felt could be alleviated by greater hierarchical control.

Although trust can be an alternative to hierarchical control, that trust must be built through shared norms and values; these may not exist between different organizations such as government and contractors.

Implications for Managers

This research does not question the basis for the government's decision to rely upon industry for its research and development; there are obviously good and enduring reasons for that policy. Given that the government and an increasing number of other organizations manage R&D through the market form of organizational control, what more can be done to facilitate the development of quality products developed within time and budget constraints?

1. Foremost in such contractual relationships is the realization on the part of organizational leaders that a substantial structural difference exists, especially in the case of government-industry (buyer/seller) partnerships. These structural differences create different risks and rewards for team members representing buyer-organizations compared to seller organizations.

2. Equally important is the need to develop trust without relying upon formalization, because formal rules could reduce trust. Alternative trust-building methods should be used, such as emphasizing shared goals and values by top management and enculturation of new team members.
3. Managers of outsourced new product development should be aware of the symbolic impact of their actions and consider how those actions will be interpreted by both buyer and seller representatives.
4. The client and contractor organizations should consider how inter-organizational rules could be instituted in ways that would facilitate, rather than erode, trust. For example, Positive Organizational Change initiatives (such as Appreciative Inquiry) could identify changes in ways that avoid the downward spiral of formalization. Likewise, an innovative approach toward trans-organizational individual (not just enterprise) rewards might be considered for improved motivation.
5. Program Managers should consider what teambuilding activities can be used to facilitate the development of trust and collective identity. Although the government has rules against the provision of benefits such as food and entertainment, opportunities may be created for government and contractor personnel to interact in social contexts.
6. Program Managers should bring the risks associated with lack of trust into explicit and conscious awareness. They can ensure the government personnel understand the problems they can cause by suggesting changes which would be overruled at a later date. They can also ensure the contractor engineers understand the loss they can create by ignoring valid suggestions from government personnel.
7. Program Managers should ensure team members understand their roles. Of particular importance is that the government representative understands the facilitation role—as opposed to a line-management role. Likewise, members of interfacing teams should be trained to understand project interdependencies and how to achieve component integration.
8. Finally, management should measure achievement in areas highly influenced by trust, such as government-to-contractor knowledge transfer and system integration.

This study was limited by the small number of respondents. Division of the dyads by both trustor and trustee yielded very small samples, but some statistically significant results were obtained. Our study is also a snapshot of the situation at a point in time, while trust is dynamic and varies over time. Therefore, we could learn more with a longitudinal study.

CONCLUSION

Trust is proposed as a way to extend market control of R&D and new product development.

We found that team members representing buyers had different relationships between control mechanisms, such as formalization and trust, than those representing sellers. Within their organizations, buyer's representatives had a positive relationship between formalization and trust, but that relationship did not exist for the seller's representatives. When representatives operated across organizational boundaries, the relationship between formalization and trust was negative, indicating that greater formalization could lead to less trust.

We encourage managers of outsourced new-product development to be aware of differences in trust and control between buyer and seller representatives in such teams.

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Panel— Out-sourcing, Employment & Public Policy

Wednesday, May 18, 2005 2:45 p.m. – 4:15 p.m.	**Outsourcing, Employment and Public Policy: Who are the Winners and Losers?** **Chair: Daljit Singh**, California State University at Fresno **Discussant: Davinder Singh**, California State University at Long Beach **Papers:** *"Military Out-sourcing: Observations, Opportunities, Conflicts and Recommendations"* Olin O. Oedekoven, Northcentral University *"Out-sourcing as an Engine of Growth for the United States"* Craig Martin, Northcentral University *"Out-sourcing and Privatization" Creating Value at What Cost?"* Dwight A. Sheldon, Northcentral University

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Discussant: Davinder Singh—California State University at Long Beach

Military Out-sourcing: Observations, Opportunities, Conflicts and Recommendations

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ABSTRACT

Observations, opportunities, and potential conflict areas concerning both defense out-sourcing and out-sourcing of the military for homeland security agencies are discussed. Observations include the impact of transformation and network-centric operations on defense out-sourcing within a volatile and uncertain national security environment. Opportunities for out-sourcing include retention of institutional knowledge, assistance with generating a network-centric force, and cost savings. Potential areas of conflict include the domestic use of the military to fight terrorism and the asymmetric nature of warfare. Recommendations are offered that suggest areas for defense outsourcing and concern the domestic employment of the National Guard.

INTRODUCTION

The US military has long relied upon a critical relationship with the industrial community to maintain and enhance readiness (Michaels, 1999). Defense contractors research, test, and develop virtually all of the military's equipment, transports, armaments, and personal gear. The military-industrial relationship is absolutely critical if the services are to meet their constitutional mission to fight and win the Nation's wars. As the services, in particular the Army, move forward to rapidly modernize and transform for the 21st Century, the industrial relationship the military has relied upon for over 200 years will become even more vital because the Defense Department cannot conceivably move forward in any reasonable fashion without its private-sector partners.

The nature of warfare and defense readiness is, however, changing. New roles, responsibilities, and requirements within the military-industrial relationship are emerging. Today's battlespace is characterized by nonlinear battlefields, asymmetric threats, global engagement, and interagency dependence (Bush, 2002). A capabilities-based military must be agile, flexible, and rapidly deployable if it is to successfully fulfill its mission (Rumsfeld, 2001). The recently published National Defense Strategy states, "We will conduct network-centric operations with compatible information and communications systems, usable data, and flexible operational constructs" (Rumsfeld, 2005). As in the past, the industrial partners of the Defense Department are essential to provide the necessary capabilities for the Armed Services. It is, therefore, important to critically examine the military-industrial relationship in light of recent trends, observations, and strategic defense guidance concerning defense out-sourcing to ensure that it is headed in the right direction.

The purpose of this essay is, therefore, to describe recent trends and observations regarding military out-sourcing, suggest opportunities for the future, discuss potential issues concerning Defense out-sourcing, and offer recommendations so the military-industrial-societal relationship can best meet the Nation's requirements. Out-sourcing is defined as the transfer of a function typically performed "in-house" by the organization to an outside or third-party vendor (Cardinali, 2001). Out-sourcing involves the movement of the work to the provider, but the responsibilities, accountability, and oversight for the services are retained by the owner. This paper focuses on the evolving nature of military out-sourcing within the last few years in terms of trends, opportunities, and potential concerns.

TRENDS AND OBSERVATIONS

Although there are numerous observations that could be discussed relative to the current and evolving nature of the military-industrial-societal relationship, a few noteworthy observations include force/structure changes, unprecedented deployments of both active and reserve forces, less distinct lines between "traditional military" and "traditional contractor support," the asymmetric nature of the conflict, the use of the military in a less traditional security role, and the recent trends regarding the use of the military as an out-source for homeland security agencies. Each of these trends and observations has had, and will continue to have, a unique bearing on defense contracting and military out-sourcing.

Current US military initiatives include modernization, transformation, re-stationing, network-centric operations, effect-based warfighting, and force rebalancing between the reserve and active components (Rumsfeld, 2005). Modernization efforts include precision munitions, lighter forces, and digital architectures for the command and control of deployed forces. Transformation measures include joint-interdependence of the services and creating capabilities-based forces. Effects-based planning and network-centric operations have replaced conventional warfighting paradigms of the last Century. Re-stationing for the military includes returning forces from Europe to create more continental US (CONUS) basing of forces (Noonan, 2005). Force rebalancing ensures that the military has the active-duty force structure needed for at least the first 30 days of the fight (Noonan, 2005). Collectively, the defense initiatives will result in an unprecedented change for the military in terms of its deterrence and warfighting postures. The Department of Defense has resisted changing end-strength, which is resulting in a need to outsource many logistical functions of the military as forces are re-designated from combat service support to either combat or combat-support organizations.

The second observation is that there is a much higher operations tempo (OPTEMPO) for the military services over the past 3 years than what has been seen in the US since World War II. The services are currently stretched between multiple theaters of operations and homeland security for the Global War on Terrorism (GWOT). Active forces are rotating between home station and deployed location every 6 to 24 months. Reserve Component (RC) forces are being activated at an unprecedented rate. Currently, over 60 percent of the RC has been mobilized at least once since the GWOT began in 2001 (Noonan, 2005). Defense contractors are used to backfill critical capabilities left vacant with the high OPTEMPO. Military out-sourcing is used to train, equip, and prepare units for their deployment.

A third observation worth noting for its impact on military out-sourcing is that there appears to be a less distinct line between what has been considered a “traditional military” role versus what is deemed “traditional contractor support” functions to the armed services (Cardinali, 2001). For example, home-station base security was typically handled by military security forces stationed at the base; however, most bases have out-sourced this function due in part to the rapidity of the security force deployments. Similarly, the security function for forward-operating bases is also being shared with military contractors. Deployed combat units have imbedded contractor support to assist with maintenance, transportation, logistical, electronic, and intelligence operations (Scharnberg, 2005). While out-sourcing the military’s logistical functions is not new, the pace of out-sourcing in recent years has clearly increased (Cardinali, 2001). The Department of Defense has been using private sources to train and equip US and foreign militaries for peace and stability operations for several years because of cost considerations, as opposed to using uniformed members for the duty (Burton-Rose & Madsen, 1999).

Blurred lines between civilian-military roles and responsibilities over the past 3 years lead to a fourth noteworthy observation: the asymmetric nature of the threat results in casualties for both military personnel and the contractors within the theater of operations (Scharnberg, 2005). The death toll of service personnel is regularly tracked and reported by the media; however, civilian casualties directly related to acts of war seldom receive similar media attention; they are barely acknowledged. Scharnberg (2005), for example, reported that since the Iraq war began, at least 232 civilians working on US military and reconstruction contracts have been killed as a direct result of combat operations. The actual death tool is probably much higher. Because contractors are deployed right along side of fighting forces and embedded within nearly every operational aspect of the military, contractors are also suffering casualties—but without the deserved attention. Of concern is that the true cost of the GWOT in terms of human lives lost may not be fully realized nor appreciated by the general public (Scharnberg, 2005). Additionally, it is worth questioning if the nation is putting civilian contractors in harm’s way without proper training, support, or appreciation for the job they are tasked to perform.

The GWOT is also resulting in an unprecedented use of the military for security and stability operations, both domestically and internationally (Noonan, 2005). The core competency for the armed services has always been to fight and win the Nation’s wars. The GWOT environment is such that the fighting and winning requires a dramatic shift away from the core competency into an area not traditionally viewed as a high priority for training and readiness. Security and stability operations require unique skills and capabilities compared to traditional warfighting. Out-sourcing has been used to create supplemental capabilities, augment the skills needed, and free-up uniformed forces for combat roles within the emerging national security environment.

The sixth noteworthy observation is the evolving use of the military, particularly the National Guard, as an out-source to the civil community. The Guard was used for airport security following 9/11, side-by-side with local police (Piatt, 2004). The Guard has been and is still being used to protect critical infrastructure in certain parts of the country in addition to its combatant roles overseas (Abshire, 2004). The Guard’s Civil Support Teams (CST) are tasked solely to provide a chemical-biological-radiological (CBR) response capability to state and federal homeland security agencies (“Plans Announced,” 2004). Although the Guard has a constitutionally defined duel-mission responsibility for both federal and state missions, recent trends in the domestic deployment of the Guard suggest that the organization may not be structured for all potential domestic missions. Moreover, one could legitimately question the appropriateness of using the Guard as an out-source for the civil homeland security community and, instead, suggest that resources being used to create the capability for the Guard should be redirected to the civil agencies to create a civilian homeland security capability.

Again, while there are many trends and observations which could be discussed relative to military out-sourcing, ones presented here provide a basis to discuss emerging opportunities and potential conflicts regarding out-sourcing, defense contracting, and the military-industrial-public relationship.

OPPORTUNITIES

Some of the opportunities for military out-sourcing include the retention of institutional knowledge, cost savings over the long-term, adjusting the end-strength mandates for the services, creating more flexible capabilities, improving domestic preparedness, providing short-term fixes to critical problems, and accelerating military modernization and transformation. Clearly the opportunities for expanding and improving the military-industrial relationship are many; the ones presented in this paper are offered to initiate the discussions on defining new roles and opportunities for the defense community.

The military rank structure is one designed purposefully to create an “up or out” culture. Warfighting is clearly a young person’s profession given the physical challenges on today’s modern battlefield. Service members are generally promoted at specific intervals based on their years of service in their current grade and military education level. Most career service personnel retire at 20 years, which for most personnel, means retiring at age 38 to 45. Senior leaders are vulnerable to retention boards that force involuntary separation (unless they are regularly promoted to the next higher grade). The basic concept behind the military system is to create a balanced age and rank structure within the confines of end-strength mandates defined by Congress. At issue, however, is that the services lose institutional knowledge and experience as service members leave the military. An important opportunity for military out-sourcing is to view the relationship as one that can retain institutional knowledge within the defense community long after service members retire from uniformed service. For example, Military Professional Resources, Inc. (MPRI) and DynCorp are private defense contractors that employ many retired military professionals, much to the advantage of both the defense community and the Nation in terms of knowledge retention, information transfer, and cost savings (Burton-Rose & Madsen, 1999).

Certainly one of the key benefits to out-sourcing is cost savings to the Federal government over the long term (Michaels, 1999). Changes in the military’s end-strength would mean more retirees and entitlements for the future. Already federal entitlement programs constitute a significant portion of the federal budget. Adding to the military’s end-strength would increase Federal entitlements. Out-sourcing, however, can create an immediate military capability without the long-term costs of entitlements. An opportunity for military out-sourcing created by an end-strength adjustment would be in terms of developing infrastructure (training bases, schools, etc.) to support a higher end-strength. As defense planners consider out-sourcing versus force structure, a consideration that should be carefully weighted is the long-term cost of an end-strength increase.

Conversely, however, Congress does appear receptive to making an adjustment in the military’s end-strength, particularly for the Army (Schmitt & Shanker, 2005). Because the Army is stretched both globally and domestically and will continue to have a high OPTEMPO for the foreseeable future, an increase in the Army’s end-strength appears warranted. As the Army rebalances, re-stations, and transforms, consideration should be made to adjust force structure to more closely align end-strength with the requirements. Currently, the Army is exceeding its end-strength cap because of the deployments and mobilizations (Schmitt & Shanker, 2005). It seems only prudent to consider making the change permanent so the Army can maintain the needed readiness levels long into the future by creating the support architecture needed to sustain the force.

Another opportunity for military out-sourcing is that out-sourcing creates greater flexibility and agility for the Department of Defense in terms of generating deployable capabilities that are military-civilian interdependent, as opposed to pure military forces (Cardinali, 2001). Just as the military is striving to achieve military joint-ness as a key tenet of readiness in order to maximize service capabilities, a military-civilian expeditionary force would have inherit strength in terms of institutional knowledge, flexibility, capability, sustainability, and deployment agility. Direct warfighting roles should remain in the uniformed services. Out-sourcing support functions of the expeditionary force would free-up resources needed for direct combat operations (Cardinali, 2001).

Out-sourcing may also improve domestic preparedness of the homeland security agencies at both the Federal and State levels. Contractors already provide resources in the event of a domestic natural or human-caused disaster. The Guard may be prepared to assist, but only if the units are not deployed and if they are trained properly for domestic employment (Oedekoven, 2003). A more enduring solution would be to create a permanent, and perhaps more reliable, domestic capability through out-sourcing and civil-agency expansion. Although the National Guard is certainly committed to fulfilling its domestic responsibilities, overseas deployments may trump readiness and availability for local and state emergences. Although Weiss (2001) argued that the consequence-management requirements for Weapons of Mass Destruction (WMD) incidents should be in the National Guard and civilian agencies, the post-9/11 realities suggest that perhaps the response should be weighted more heavily in the civil community given the current availability, or lack thereof, of the Guard.

Out-sourcing can provide the much-needed help with military educational requirements while the military creates the educational infrastructure to support programmed schooling. The military's training base is currently stretched to the breaking point, and contractors currently provide military educational opportunities that the military otherwise would not be able to provide (e. g., distance education by the Senior Service Schools, the Army's Force Management School, the Reserve Officers Training Course, etc.). The rapid pace of technological change is also such that the military cannot be as responsive as it should be to the change. Out-sourcing allows the military to keep pace with technological improvements via equipment acquisition, training, and maintenance. An additional benefit of educational out-sourcing is that institutional knowledge can be retained and shared—provided that the contractors employ retired service personnel to instruct the programs.

Out-sourcing is critically important if the military is to successfully transform and modernize within the timelines established by the Department of Defense. It only makes sense that contractors be used to conduct the training for new equipment fielding in order to free up billets for combat and combat-support personnel scheduled for deployments. Out-sourcing is a proven method for helping the Army transition; it improves combat effectiveness at a faster rate than would otherwise be possible without the participation of the private sector (Harvey, 1996). Out-sourcing will be needed to create the training platforms, simulators, and facilities for the Army's modular force. If more resources were directed to military out-sourcing, it would be possible to accelerate the transformation/modernization program which is currently scheduled well into the next decade and possibly beyond.

Many other opportunities for military out-sourcing certainly exist given the nature of the national security environment. What is needed is greater imagination and creativity to better create and leverage the industrial capabilities that could support national defense.

POTENTIAL CONFLICTS

Out-sourcing is certainly not free of risk and conflict, both perceived and actual. It is important to recognize and mitigate risks associated with out-sourcing to create the defense posture the GWOT demands. Some of the potential trouble spots include: the domestic use of the military, long- and short-term costs, theater of operations casualties, and understanding and appreciating the asymmetric nature of warfare. Potential trouble areas can be divided into two areas: the use of the military as an out-source and the use of civilian organizations as an out-source for the military.

The nature of military training is that forces are used to “fight the enemy.” The domestic use of the military relative to acts of terrorism (both foreign and domestic) could lead to a potential conflict: the domestically deployed force could view US citizens as “the enemy.” The domestic employment of military forces must be such as not to create a value-conflict within the service membership. If the military, in particular the National Guard, is deployed as an out-sourced resource for civil homeland security agencies, the civil and military leadership must recognize and effectively mitigate the potential problem of “enemy recognition.” One need only look back to the Los Angeles riots in 1992 (Schnaubelt, 1997) and the riots and protests of the late 1960’s and early 1970’s to see the potential risks associated with the domestic employment of the military.

Federal law limits the domestic use of the military to conduct traditional law-enforcement duties (Schnaubelt, 1997). The Posse Comitatus Act prohibits Title 10 (Federal Active Duty) service members from a number of domestic law-enforcement roles. The military can work around this restriction by employing Air and Army Guard service members in a State Active Duty status. Funding for the deployment is the issue with this solution, however, because Title 10 service is paid for by the Federal government, whereas State Active Duty service is paid for by the States. It is important to learn from both the successes and shortcomings during the 1992 Los Angles riots and the post 9/11 domestic deployments if we are to use the nation’s military as a security out-source for civil authorities.

A third potential trouble spot regarding military out-sourcing is within the area of cost and bureaucracy creation. There is certainly a strategic desire by the Defense Department to keep costs down by not changing end-strength. At the same time, however, the Department appears to be creating a much larger defense-contractor bureaucracy to address the short-term needs for out-sourcing. Recent media attention on the possible misuse of government funds regarding Halliburton in Iraq is due in part to the seemingly complex bureaucracy created to support the multi-billion dollar contracting program. The Department of Defense does not appear to be organizationally structured to best administer its huge defense contracting program. Media attention on the issue creates public perceptions of trust issues and support for the defense effort.

Another area of concern regarding military out-sourcing in light of recent trends and observations is the rising number of non-military casualties within the theater of operations from direct combat actions (Scharnberg, 2005). The public appears to not focus on the number of contractor causalities, only on the daily troop casualty figures. As such, the public might not be seeing an accurate picture regarding the strategic situation and the cost of the GWOT. The potential conflict in this perception is that the nation appears to place a higher value on a service member's life than it does on a civilian defense contractor's life (Zucchino, 2005). The Nation must not travel down this very slippery moral slope of making a value judgment regarding the loss of a combatant versus a noncombatant American.

A fifth potential area of conflict concerns an appreciation for the asymmetric nature of war. Clearly, asymmetric warfare will now be the norm rather than the exception. No military in the world can go toe-to-toe with the US military and expect to win a protracted fight unless the enemy conducts asymmetric operations (Rumsfeld, 2005). An asymmetric battlefield means blurred lines between the locations of friendly and enemy troops. Historically, civilian contractors tended to operate within the theater or corps support areas, usually well away from the front-line battle. Today and for the foreseeable future, contractors, even those in support roles, will be operating throughout the asymmetric battle space (Zamparelli, 1999). The asymmetric nature of the threat may be relatively clear within the Defense community; however, the general public may still not fully appreciate the combat environment for the GWOT. Potential concerns regarding military out-sourcing within the asymmetric environment include a public that does not understand defense requirements nor appreciate the true costs of the campaign.

No doubt there are other areas of potential conflict and concern regarding military out-sourcing. As a nation and a defense community, civilian and military leaders should be forward thinking regarding potential conflicts and take the needed measures to more effectively manage the risks involved.

RECOMMENDATIONS

The following recommendations are offered to improve both the out-sourcing for the military and regarding the use of the military as an out-source.

1. Transformation and modernization of the military to create a network-centric-based force will require an integrated command and control architecture that includes all of the services and leverages both existing, as well as emerging, capabilities to create joint synergy. Specific opportunities for out-sourcing and acquisition include secure wireless technologies operating in remote and urban environments over long distances.
2. A network-centric force needs more effective tools to better measure the sociological effects of its operations. Much depends on the force achieving strategic and operational effects outlined in the theater and campaign plans; yet, few resources and specific tools exist to qualify and quantify the effects of the operations.
3. The Department of Defense should critically examine the employment of the National Guard's Civil Support Teams to ensure that they are fully integrated into the civilian emergency response network. It may also be prudent to examine if the CST should be a pure civilian organization that can tap into military resources but remains under a state homeland security agency rather than the military departments of the Guard.
4. The Nation should focus on building up the capabilities of the civilian emergency response communities and security agencies instead of being dependent upon the military, in particular the National Guard. The nature of

the National Security environment is such that the Guard will be regularly deployed and may not be available as originally planned.

5. The Country needs to recognize the true cost of war in terms of both military and contractor deployments and casualties. Perhaps the Department of Defense could re-examine the historical lessons learned during World War II concerning the Merchant Marines and develop a new defense organization that would more formally recognize and acknowledge the heroic efforts of defense contractors within the Theater of Operations.

Military out-sourcing has been and will continue to be absolutely essential for national defense. Like any program or business, continuous improvement is needed in the system to better realize potentials and reduce risks. Just as the military is transforming to meet 21st-Century defense challenges, so too should the military-industrial-public partnership adapt to meet changing out-sourcing needs.

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Out-sourcing as an Engine of Growth for the United States

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While pursuing his PhD, Craig has been teaching graduate business courses, primarily in the University of Phoenix Online and FlexNet modalities. His teaching experience includes instructing for two years at University of the Ozarks.

Prior to entering the academic world, Craig was an executive and CEO with several corporations for 25 years. As publisher and president of four daily newspapers in the Midwest and California, Craig enjoyed professional relationships with DoD units of the Air Force. He also held several positions in the healthcare industry, including marketing director of Latin American operations for Baxter, Inc.

Craig served as a Supply Corp Officer in the US Navy in the 1960s, and was stationed in Rota, Spain, and Jacksonville, Florida. He was selected to attend the civilian program of the United States Air Force Air War College in 1993.

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ABSTRACT

Proponents of out-sourcing cite numerous benefits accruing to those organizations pursuing out-sourcing. Yet, opponents decry the practice as the primary cause of job loss in the United States. This paper will demonstrate that the critics' perceptions are not supported by the actual experiences of organizations. Research has found, instead, that out-sourcing leads to the creation of more jobs (due to capital flows resulting from the beneficial impacts of out-sourcing) than are eliminated due to the process.

The discussion concludes with a proposal for creation of partnerships between the Federal government, state governments and non-governmental entities to advance the skills and knowledge of those persons unemployed due to out-sourcing to prepare them to reenter the workforce in newly created future positions.

OUT-SOURCING AS AN ENGINE OF GROWTH FOR THE UNITED STATES

The recent 2004 presidential campaign highlighted the ongoing debate over out-sourcing and whether it is beneficial or detrimental to the American workforce. Business executives, laborers, economists and scholars are all voicing their opinions in the continuing discussion, arguing the benefits of out-sourcing activities versus the costs and adverse consequences. While recognizing the negative outcomes of out-sourcing, this paper will focus on the many benefits derived from out-sourcing acquisitions of products and services.

Benefits of out-sourcing take the form of enhancing innovation, producing value-added outcomes, advancing technology and providing additional funds for reinvestment. Trade among organizations and countries results in economic growth, and it will be demonstrated in this study that such activity leads to positive growth in employment at the macroeconomic level in the United States.

Perceived detrimental consequences of out-sourcing are usually limited to arguments regarding job loss and the loss of control by the organization participating in out-sourcing. Other research has shown that the latter is effectively addressed by employing modern management techniques to measure performance against desired outcomes. In the case of the former, this researcher has concluded that, while some job loss does occur within organizations or industry segments due to out-sourcing, the activity at the macroeconomic level can be shown to drive positive employment growth in the United States. Further, with the introduction of innovative and/or governmental programs to motivate the use of educational resources to assist in the transition of workers adversely impacted by out-sourcing, various case studies have indicated that most adverse impacts of out-sourcing relative to employment can be mitigated at the microeconomic, or organizational, level.

GLOBAL OUT-SOURCING BENEFITS AT THE MACROECONOMIC LEVEL

Out-sourcing—acquiring products or services from an entity independent of the organization—is not a new concept. Even when families and clans were the largest form of organized government, it made sense to out-source in order to take advantage of the skills of others outside the family unit (division of labor) and to employ outside labor to assist the family unit in the production of all the necessities for survival (labor saving).

On a larger scale, the Scottish economist David Ricardo advanced the theory of comparative advantage of production between countries as a reason to out-source. Ricardo's theory holds that greater growth in the Gross National Product (GNP) occurs if each county produces and trades those products for which it holds the comparative advantage of adding value to than if each country produces all products and does not trade (Ricardo, 1817, 163-164).

That Ricardo's theory is valid can be seen in research that illustrates that countries participating in trade in the 20 years prior to 1997 experienced GNP growth of 4.9% on average, while those that did not participate grew at a rate of less than 0.7% (Hill, 2003, 145-152).

Researchers logically ask: Did capital flows lead to similar beneficial results? Again, research shows that the flow of capital, or Foreign Direct Investment (FDI), *from* the United States results in positive flow of capital *to* the U.S. in the forms of profits, component products, services and investment.

The inflow of products and services to the U.S. directly related to FDI rose to 34% of total imports by 1993, and this percentage has remained fairly constant ever since (Aquilar, 1996). Profits and cash flow returning to the U.S. from subsidiaries of U.S. multinationals have grown substantially since the 1970s, as measured by Bureau of Economic Analysis (BEA) annual data (BEA, 2004).

Positive investment flow as a direct result of trade and FDI has also come in the form of FDI from foreign investors. Entities that are at least 50% owned by non-U.S. citizens contributed about 10% of all investment capital in the U.S. in 2003, enabled 5.1% of all U.S. employment in that year, purchased over $1.0 trillion in goods and services from U.S. entities and made major contributions to American research and development (Slaughter, 2004).

Out-sourcing in the form of capital also has been shown to lead to intellectual benefits. By out-sourcing software development to India, among other countries, U. S. developers have been able to allocate an additional $30 billion since 2003 to other research and development projects that will drive innovation and productivity (www.amrresearch.com).

In-sourcing of FDI, which has been positively correlated to the out-flow of FDI in the US, has resulted in over 14% of the annual US research and development expenditures flowing from foreign subsidiaries located within this country (Slaughter, 2004, 6-7).

While our primary purpose in this study is to explore the benefits of outsourcing for the US, it is interesting to note that research confirms similar benefits to other countries from similar flows of capital. This research demonstrates the positive contributions of trade and capital flows between Japan and the US, between the EU (European Union) and the US, between the three North American Free Trade Union (NAFTA) countries, and between Mexico and Malaysia.

ORGANIZATIONS BENEFITING FROM GLOBAL OUT-SOURCING

The macroeconomic benefits discussed above can be apportioned, on a microeconomic basis, to individual organizations, including private and public entities. For example, profits and cash flows from subsidiaries flow to the US parent, as do components for insertion into products in the US and finished goods ready for resale. While research confirms this on a case-by-case basis, this writer has not identified a comprehensive study demonstrating the anticipated conclusion.

Initially, a primary benefit of out-sourcing from the US, especially to developing countries, was the growth in profits from reduction in labor costs. Though these savings were partially offset by increased transportation costs, wage differentials were substantial enough to justify FDI. However, with the average life of a labor-rate-advantage study now being less than five years, a more recent study has found that adequate Return on Investment (ROI) cannot be earned based on labor-cost savings alone (Bartlett, 2004, 7-13).

In 2003, McKinsey & Company, a global consulting firm, found that shifting jobs off-shore was driven more by technological advancements in telecommunications and productivity enhancements than by efforts to shift to lower wage areas. The research found benefits to the US economy from cost reductions, the creation of new revenues as a result of new services offered at lower prices, and increased value added to firms as a result of US workers shifting positions, all of which led to increased profits (Geewax, 2004).

Foreign capital invested in plants and equipment and to procure inventory from US companies will naturally benefit the American entities, and technology advancements and innovation flowing to US entities are an immediate and direct contribution to the increased value of those entities, public and private. Moreover, FDI into the US resulted directly in the growth of the workforce by 5.1% in 2003. Two subsidiaries of foreign investors experiencing such job growth were GKN Aerospace, located in St. Louis, Missouri, and Saint-Gobain, located in the suburbs of Atlanta, Georgia (Slaughter, 2004, 4-5).

Similarly, Federal and state governments accrue benefits in the form of taxes resulting from positive investments and profit flow. In particular, the Department of Defense (DoD) has benefited directly from foreign capital flow in the past. Surplus equipment is sold to entities overseas, and services in the form of training are provided within the US to members of foreign military.

Just as private firms realize benefits from the procurement of services from foreign firms, cost savings and value-added activities are likely to be realized by the DoD when non-strategic services are procured off-shore. For example, in the DoD's competitive sourcing program, research shows savings of 44% in labor costs while the DoD still effectively improves quality of services added (Gansler, 2004). There is no reason to suspect that similar outcomes cannot be realized whenever bidding is employed.

In summary, there are multiple benefits emanating from out-sourcing goods, services and capital from the US to overseas locations. Though the above discussion is not comprehensive, it is an overview of the kinds of benefits that can be reasonably expected by those who participate in outsourcing.

DETRIMENTAL CONSEQUENCES OF OUT-SOURCING

The perception that out-sourcing leads to the loss of jobs is long-standing. Governmental bodies around the globe have long cited this argument to justify the enactment of trade barriers against imports or against the in-flow of investment capital (Hill, 2004, 181). Labor unions have routinely bargained job retention when companies have introduced out-sourcing as a means of acquiring new technology or knowledge. And the continuing political and economic debate is centered on the conviction that out-sourcing does indeed lead to job loss. But is this a valid perception? And, if it is shown to be valid, to what extent are the consequences detrimental? Do detrimental outcomes in fact outweigh the benefits enumerated above?

At the macroeconomic or national level in the US, evidence does not support the contention that out-sourcing is basically detrimental. Careful review of the two employment series maintained by the Bureau of Labor Statistics (BLS) since their inception suggests a different conclusion. As we shall see, each of these labor employment series demonstrates continual annual growth in the number of persons employed, thus illustrating that more jobs are created each year than are destroyed for various reasons, including out-sourcing.

Although the decade of the 2000s has witnessed much political rhetoric to the contrary, using either of the two BLS series, we can see the total number of public- and private-sector jobs has increased quarterly and annually. And growth has occurred in most sectors, with the primary exception of manufacturing (www.bls.gov/cps/home.htm).

Compiled since 1946, the payroll survey, which statistically extrapolates total and sector employment by sampling 300 thousand companies monthly, has continually trended upward in each decade, regardless of the point in the economic cycle in which the country resides (www.bls.gov/ces/home.htm). However, as the nature of work has shifted from the plant or office to include the home office, economists have come to realize that the population survey, which samples 60 thousand households monthly, provides a more accurate picture of total and sector employment than the payroll survey. In its totals, the population survey adds the following sectors to all sectors contained in the payroll survey: Agriculture, self-employed small business owners, and all persons who work under contract with the government or private firms (Fraser, 2004). Taken since 1998, the population survey has likewise trended upward continually.

A particularly vocal industrial segment, whose rhetoric has contributed to the perception that out-sourcing leads to job loss, has been the US manufacturing sector. That job losses have occurred in manufacturing cannot be argued, and this condition has persisted in every country with a substantial industrial sector, even while manufacturing out-put has continued a growth trend (Geewax, 2003). However, studies have found that the loss of less-skilled jobs in manufacturing and other sectors due to out-sourcing has not necessarily led to a reduction in total jobs. A World Bank study found that large, developed countries such as the US and Canada and developing countries such as China and Mexico were only marginally affected by such job losses because there was a corresponding increase in skilled jobs created. Firms employing higher-productivity strategies (such as digital technology) created a greater number of replacement jobs than those that did not (Batra, 2000).

Another study supported the concept that manufacturing jobs are continually “churning,” with marginally more jobs being created than being destroyed. While this study did not relate its findings to out-sourcing and in-sourcing, it demonstrated that churning has occurred for many decades; therefore, the study called for further exploration of the causes (Klein, 2003).

Economist Paul Ormerod discovered the positive, exponential relationship between growth in corporate profits and retention in the percentage of profits—which is then used for reinvestment and growth in employment (Ormerod, 1997). So, it would seem that the ever-increasing flow of profits from foreign subsidiaries during the past 30 years, which is in contrast to the declining percentage of dividends being paid (Fama, 2001), has created a very powerful driver for employment growth in the US.

Further, substantial research by this writer strongly suggests that a direct, positive correlation exists between the growth in FDI flowing outward from the US and the flow, in the forms of capital investment, the importation of inventory and the retribution of profits, toward the US. All of these flows have contributed to the growth in profits in the past 30 years for the US-based multinational corporations. As noted above, this growth has been directly related to the growth in home-based employment in the US.

Finally, a study released in 2004 using the Commercial Activities Management Information System (CAMIS) database illustrated that, while approximately 5 percent of DoD jobs which competed successfully in the Department’s competitive-sourcing programs since 1995 were involuntarily eliminated, competitions led to savings on average of 44% and to improvements in quality of services provided to customers (Gansler, 2004, 6-7). The conclusions contained in the above comprehensive study appear to parallel many of the results (cited previously) obtained from the research into private activities.

EMPLOYEE TRANSITION FROM JOB LOSS TO JOB GAIN

Research and analysis of job loss versus job creation lead this writer to conclude that:

- The benefits derived from the use of out-sourcing are numerous and beneficial to national organizations based in the US.
- While job loss due to out-sourcing has occurred within organizations, at the microeconomic level, benefits usually outweigh the detrimental consequences to employment within the organization.
- While some job loss has occurred due to out-sourcing from the US, the total number of jobs has continually demonstrated an upward growth trend since the beginning of data collection shortly after the culmination of WW II.

While these conclusions may be good news on the macro- and microeconomic levels, if one is an unwilling participant in a reduction in workforce, it can be inferred that a serious, if not critical, problem confronts that individual. Historically, initiatives to provide unemployment assistance and more jobs of the same kind have been seen as a solution, but these no longer address the core problem. The complicating feature is identified in numerous futuristic economic forecasts: while products and services will not be of less value than those of the present, the requisite labor skills and knowledge will often not be possessed by the workforce in the US (Klein, 2003).

Both President Bush and Federal Reserve Chairman Alan Greenspan have called for educational initiatives to address the problem of persons whose employment is terminated due to out-sourcing. Certainly, organizations participating in the changing workplace will be well positioned to identify the skills and knowledge needed by employees, at least within their own domains. Indeed, the argument can be made that these decentralized voices are superior to the centralized voice of the Federal Government in identifying their potential employees' educational needs.

It is this author's conclusion that a variety of partnerships between non-governmental entities and the Federal government could be formed to establish effective programs that would enhance the requisite skills and knowledge of those individuals involuntarily separated from existing positions. The government's role would be limited to establishing policies to financially motivate organizations to provide assistance in the form of training or education; these programs would make it possible for individuals to identify and acquire the knowledge and skills for employment which would best serve them in the future.

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Out-sourcing and Privatization: Creating Value at What Cost?

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Mr. Sheldon has contributed to research and development projects in Micronesia, Pacific Asia, Melanesia, Polynesia, and North America. In addition to his work on archaeological research projects and ethnographic studies on Guam and in the Northern Marianas Islands, he has worked on development projects related to agriculture in the Visayan Islands of the Philippines. Mr. Sheldon has authored, co-authored, and edited more than two dozen non-published technical reports of archaeological work including the benchmark studies, *An Archaeological Report on Miyama Hills, Guam* (1990) as well as *An Archaeological Assessment of Kagman/As Matuis, Saipan, CNMI* (1991). Mr. Sheldon worked for the Government of Guam (1992-96) as staff to three commissions including the Territorial Land Use Commission and the Territorial Seashore Protection Commission. He additionally supported review of infrastructure project and development applications before federal agencies throughout much of Micronesia. Mr. Sheldon is presently engaged as a consultant with Protec-services.com in Florida.

ABSTRACT

This report examines aspects of one form of privatization: Out-sourcing. The paper treats aspects of recent national publicity about the "off-shoring" of American jobs and displacement of workers in the US. The presentation promotes an informed stance on many perceptions about the loss of American jobs in a competitive global economy. Discussion of the contention that corporate tax codes need revision in order to protect American jobs, plus facts on how many jobs are lost due to outsourcing is provided. Lastly, this discussion shows how out-sourcing has actual benefits for American business and consumers in a greater global economy.

INTRODUCTION

Out-sourcing was once viewed differently from how it is seen in the context of current business practices and in a newer, global economy. At one time, out-sourcing was considered to be a last-ditch effort that troubled companies looked to in order to solve the problems of their "bottom lines." Much more recently, out-sourcing has become recognized as the strategic management tool that it is, allowing companies of all sizes to remain centered on their core functions and their core competencies. Smaller companies have moved to out-sourcing for not only the completion of peripheral tasks but also to handle multiple tasks that are tied directly to their core function.

Through out-sourcing, a company can work with those players that are most competent to perform specific functions so tasks can be preformed at a greater level of quality and can often cost less than if the company had attempted to do the work itself. Out-sourcing can save money and can allow companies to better utilize resources. Companies can have smaller workforces that do not require the additional administrative tasks inherent in a larger organization (Ivancevich, Lorenzi, Skinner, Crosby, 1997).

Out-sourcing to offshore companies has garnished a new standing in the business world: Recent debate on the topic has placed out-sourcing in the national spotlight. Because of the ideal that "off-shoring" acts to displace workers here in America, out-sourcing has gained a reputation as being bad for the Unites States. Certainly, savings in cost related to labor can be realized when the most competitive provider is utilized. The issue of added value is weighted by the matter of extraneous and societal costs, an issue actively debated in recent political campaigns.

OFF-SHORING AND THE RHETORIC OF CAMPAIGNS

While the purpose of this paper is not intended to be centered on aspects of the political process enshrined in the course of presidential elections, discussion of how that process has effectively created a greater public interest in off-shoring is necessarily in order. Among the most contentious issues of the recent campaign was that of out-sourcing work overseas and the subsequent threat to jobs in the US. During his 2004 presidential campaign, Senator John Kerry actively promoted the premise that the corporate tax code was largely responsible for the problem of sending American jobs overseas. The senator announced that he had a plan to remedy much of the problem. In key battleground states and in those states in which there had been substantially high levels of unemployment, Kerry made this issue the cornerstone of his campaign.

Additionally and to fuel the rhetoric of debate, Kerry often placed the blame for much of the problem of unemployment caused by off-shoring on the actions of his opponent, George W. Bush. Many of the party loyal picked up on the mantra while others, inside and outside of the party, suggested that out-sourcing jobs overseas was a minor problem and that Kerry's plan would accomplish very little in correcting it.

President George W. Bush actively contested Kerry's controversial proposal. The President continues to not support the senator’s plan; the Bush administration supports measures that allow US-based multinationals a larger tax credit on their overseas income. While Democrats argue that such a plan would only increase incentives to move jobs overseas, the administration counters that its own approach would help US firms compete globally with foreign firms that are able to otherwise avoid US taxes altogether.

Senator Kerry had announced his plan to keep jobs in this country through a new economic plan for America. In part, the plan called for ending tax incentives that encourage American companies to send jobs overseas.[1] As presently allowed, corporations would still get a credit for any taxes paid in other countries. However, Kerry had proposed a tax immediately upon foreign income: businesses would no longer be able to defer the US taxes indefinitely.

Kerry proposed that the corporate tax rate be cut by 1.75 percentage points, to a top corporate rate of 33.25 percent. Kerry would have allowed a one-year "tax holiday" to allow businesses to avoid US taxes on repatriated earnings that would otherwise have been left overseas. The senator would also offer a tax credit to companies when they choose to hire workers in the US rather than out-sourcing jobs overseas.

In sync with any rhetoric planned to tug on the emotions of the electorate, one must state the certainty of the very human toll of off-shoring jobs. Before attempting a discussion that may appear unattached to the real anguish of those persons who have lost jobs or that might

[1] The plan additionally called for increases in education and for investments in new technologies (such as alternative fuel sources) that would create jobs in this country.

lose a job in the future, this writer wishes to acknowledge that such loss is regrettable. To any person, family, or community that must deal with the consequences of the loss of even a single job, off-shoring must necessarily seem to carry substantial and irrefutable costs.

As an engaged electorate continues to assimilate the differences in rhetoric between each camp, their representatives on Capitol Hill have begun a continued debate. Beyond the publicity gained during the campaigns, perhaps the single greatest effect of the exchange on American jobs and corporate taxes was that a fully engaged legislative branch continued the debate on the equity of tax codes and of the plight of the American worker. American lawmakers continue to debate the practicality and the possible ramifications of making specific changes in the code.

BEYOND CAMPAIGN RHETORIC: CONGRESSIONAL DEBATE ON CORPORATE TAXES

Moving past all the campaigns, the assertion that American businesses are “off-shoring” jobs merely to avail themselves of advantageous tax codes has some merit: There is indeed a tax break for US-based multinational corporations to conduct operations overseas. However, no seated president can be blamed for the situation because the codes have existed in much of their present form for decades. In discussion of issues brought forward during the campaign—especially the matter of outsourcing American jobs overseas—some specific points may well be succinctly addressed to further a greater discussion of out-sourcing.

Much of the problem with the present tax code is centered in the fact that it has not kept pace with changes in the economy of the United States and in a newer global economy. US International tax policy is based on tax principles that were developed in the 1950s and 60s.

There are at least two kinds of out-sourcing relevant to this report and which are subject to existing or revised corporate tax codes. In one type, an American company closes a facility in the US and opens its replacement in a foreign country. This form of out-sourcing may or may not be planned to deliberately take advantage of the tax "loophole" and to defer US taxes. In this scenario, and since the American company retains ownership of off-shore operations, often choosing to reinvest income abroad, the company would be impacted by changes in the tax code.

A second type of outsourcing—the primary type to affect information technology (IT) workers—involves American companies subcontracting work (and displacing workers in the US) to off-shore companies. Since the hypothetical US company doesn't own the off-shore facility, the company doesn’t enjoy any tax break because it doesn't generate off-shore profits. In this type of out-sourcing, only deliberate incentives built into tax codes address the issue of the displacement of workers.

Some say that a plan similar to that which had been proposed by Senator Kerry would not accomplish much to solve the problem, or that such a plan could actually hurt American businesses and impede economic recovery. Some experts say that such a fix could actually send more jobs overseas as businesses seek to relocate abroad.

Tax incentives to increase retained earnings exist when the US corporate tax rate exceeds that of the country in which companies do business. Furthermore, the US also taxes income that US-based companies earn in other countries when such profits are repatriated to the US. Profits that remain invested overseas never get taxed at the higher US rates.

Apparently, the corporate decision to retain income outside the US is becoming more prevalent, and the amount of unrepatriated foreign earnings is growing substantially. In a report last year, the non-partisan Congressional Research Service said that such earnings had increased to $639 billion in 2002 from $403 billion in 1999 (US House, 2004).

DOMESTIC EMPLOYMENT AND OUT-SOURCING

Many economic analysts state that out-sourcing jobs overseas is a fairly minor problem compared to the total picture of the unemployment situation. Most experts agree that elimination of the present tax break would not end the off-shoring of many American jobs. While many multinational businesses choose to not repatriate earning because of the allowed savings in tax burdens, there are other important reasons that propel work to operations abroad. Certainly, the fact of lower wages realized in many foreign workforces is an extremely important factor. In fact, the reduction in costs of utilizing foreign workforces alone is a very powerful incentive; yet, there are other reasons beyond tax breaks and wage differences that drive out-sourcing.

For one thing, customer services must follow consumers. In the global economy, a growing proportion of consumers of American goods and services live outside the US. Many companies rightfully strive to be near their global customers in order to best serve them.

Factors of the economics of a greater global marketplace alone help to drive out-sourcing. Off-shore companies that contract to perform services continue to make substantial strides in investing in forms of higher-level technology and processes (as well as training and human resources) that add value to quality-based products.

Additionally, foreign governments that are home to service-based companies have succeeded in putting reforms in place that are highly conducive to increased business activities. In India, for example, telecommunications costs in have dropped by 70 percent over the past several quarters (McDougal, 2005). Since the integration of countries from the former Soviet Union, Eastern European countries now contribute ever-increasing numbers of highly skilled workers to the global workplace. The World Trade Organization has welcomed the economic and labor-rich giant, China. Globally, many antiquated trade barriers have been dismantled.

Development-oriented policies by governments, in cooperation with industry, have helped to increase transportation and communications around the world. Plummeting relative transportation and communications prices have allowed workers to be able to join the ranks of higher-level workforces. In all, a newer, global economy has continued to grow by the recent addition of 300 to 400 million highly educated workers.

It its report, “Extended Mass Layoffs Associated With Domestic and Overseas Relocation, First Quarter 2004 Summary,” the Department of Labor concluded research on the matter of American jobs going overseas. The research found that out-sourcing jobs overseas accounts for a small proportion of the millions of American jobs that are lost each year. Of course, there are no official figures on the exact number of jobs that have moved overseas; yet, the Labor Department summary is one of the best sources of information on the impacts on labor as a result of off-shoring. The report looked at only those companies that lay off 50-or-more workers at one time for a period of 30 days or longer. The report indicates that only 2.5 percent of major layoffs in the first three months of 2004 were the result of off-shoring (Department of Labor, 2004).

One must be aware that the vast majority of jobs in the United States are those types that require geographic proximity to the end-user—jobs that produce goods and services that must be consumed locally. Such types of jobs include construction, agriculture, certain types of services, personal care and medical care, as well as restaurants and forms of entertainment and recreation. Out-sourcing these types of jobs overseas is not feasible. Other types of jobs that require production portions and processes that are fairly complex, interactive, or personal are relatively difficult to send abroad. Due to the sheer size of the American workforce and the number of workers employed in the above types of jobs, possible off-shoring would affect less than 2 percent of American workers.

Ben Bernanke, Governor of the Federal Reserve, has noted that the annual total number of jobs lost to "off-shoring" is approximately one percent of all jobs lost. He estimates that the US economy lost a total of about 15 million jobs each year over the past decade. At the same time, the same economy created an average of approximately 17 million new jobs each year. Bernanke said the portion of jobs lost to out-sourcing is quite small (Bernanke, 2004).

It is clear that off-shoring has had a relatively modest impact on unemployment when compared to all the other economic factors. Factoring in economic downturns, decreased demand, downsizing, streamlining, or other spoilers causing workers to lose jobs, the actual job loss resulting from off-shoring has been relatively minimal as a percentage of the total jobs lost in the United States.

Additionally, forms of improved productivity through the use of automation and improved processes (as well as through the availability of advanced forms of tools) are expected to continue to have the greatest impact on job creation and losses in this country. By the year 2015, the effect of those factors on IT-job displacement is expected to be six times greater than the impact of off-shoring (McDougal, 2005). Job losses from a greater level of productivity must be balanced by job creation—by newer types of industries that create and build such advanced tools, processes, and forms of automation.

Beyond the “bottom-line” loss of actual jobs, there are real costs to those American workers who have otherwise been able to hold onto their job. For several reasons, off-shoring contributes to wage levels that are stagnant and to benefits levels that are declining.

Off-shoring has the effect of forcing American workers to compete within a global economy with a workforce that continues to grow at a rate indicated by the recent addition of hundreds of millions of highly educated workers. Additionally, and due to practical management considerations, US workers find that the level of benefits provided to them is normally adjusted downward to more closely approximate the levels of benefits offered to workers in other countries. Presently, all workers do not enjoy benefits such as 401(k) plans and vacation pay. In some countries, there is less need for employer-paid health plans; yet, the health care system in the Unites States is relatively much more expensive than in other countries, so employer-subsidized health plans are more of a necessity.

THE UPSIDE OF OFF-SHORING

Conversely, recent studies show that when companies move some jobs abroad, the savings in costs stimulate job creation at home. Moving jobs overseas may have a direct short-term (adverse) consequence. Yet, in the long term, a greater global economy increases this country's total economic growth while increasing real wages and improving the national and global standard-of-living.

An examination of the amount of business that is out-sourced from other countries into the US shows a significant trade surplus in services, in contrast to a less-significant trade deficit in goods. In 2002, the US "in-sourced" nearly $29 billion in business while it out-sourced less than $11 billion. This shows an overall surplus of $18 billion (Bernanke, 2004). The US in-sources mostly high-value services from foreign users; yet, in contrast, it out-sources relatively less-valuable services (Bernanke, 2004).

CONCLUSION

A solution to any problem of out-sourcing that is based on tax amendment is extremely complicated and controversial. No would-be remedies can ever impose US taxes on income earned in another country; enforcement of any such provisions would be impossible. Additionally, many businesses would merely find new ways to delay or avoid taxes. For this and other reasons, much of the root of the problem of displacement can not be found in the tax codes.

It remains nearly impossible to measure exactly what factors drive off-shoring and which related factors exacerbate unemployment. Companies can rightfully continue to assert that the main reasons they locate plants in other countries are to be near foreign markets and to be able to provide a better quality product.

In fact, off-shoring accounts for a relatively small portion of US unemployment. There is no denying that off-shoring can displace American workers; however, it does not cause the tectonic shift that many persons ascribe to it. The effects of out-sourcing on the US and in industrialized nations tend to be disproportionately exaggerated in popular discussion by politicians.

The best way to view out-sourcing is to consider it a form of adjustment in the greater environment of a global marketplace. Certainly, consumers around the globe benefit from this new economy by being exposed to a greater amount of high-quality goods and services at low prices. It must be stated that, with such access to goods and services, there must necessarily be some downside. Americans can no longer expect that, as has been the case in previous decades, the former “firewall” of national boundaries will negate international pressures in the current global economy.

Once, the strength of America’s economy was centered in the capacity of its abundant natural resources and the sheer capability of its workforce. The nation continues to possess vast resources. The total of its workforce is the best-trained and best-equipped on the planet. Many countries continue to make inroads to compete with the US, especially in segments of service industries.

A newer, global economy provides substantial benefits to consumers and to workers around the world. Enhanced levels of quality in products and in services is expressed by the end-product of many interconnected players that no longer must be found in geographic proximity. The United States continues to be a leader in fostering innovation and in the creation of new technologies. The country’s businesspersons show a remarkable capacity to respond faster and smarter to the commercialization of these technologies. Protectionist policies of the past will only serve to diminish the benefits of participation in a modern environment and global economy in which American products are required. The increasing ease of transferring digital information around the world is matched by the subsequent dislocation of workers. Optimally, American workers should be displaced upwards, to high-levels positions in an ever-expanding theater of new processes and new forms of technology. America's preeminent resource today is its ability to innovate; the greatest possible problem for the US is the potential loss of such unsurpassed competency.

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Panel—Issues in Program Management

Wednesday, May 18, 2005	Acquisition Logistics/Support
2:45 p.m. – 4:15 p.m.	**Chair: Rear Admiral James B. Greene, USN (ret.), Naval Postgraduate School** **Discussant: Captain Stephen Huber**, Naval Surface Warfare Center, Port Hueneme Division **Papers:** *"A Decision Support Model for Valuing Proposed Improvements in Component Reliability"* Keebom Kang, Naval Postgraduate School Michael Boudreau, Naval Postgraduate School Uday Apte, Naval Postgraduate School *"Understanding the Impact of Mandated RFID Compliance on the DoD Supply Base"* Kenneth J. Petersen, Arizona State University Mark A. Barratt, Arizona State University *"Logistics Transformation through Sense-and-Respond Logistics Network"* Jacques S. Gansler, University of Maryland Kenneth A. Gabriel, University of Maryland

Chair: Rear Admiral James B. Greene, USN (ret.) – Acquisition Chair, Naval Postgraduate School. RADM Greene develops, implements, and oversees the Acquisition Research Program in the Graduate School of Business and Public Policy. He interfaces with the DoD, industry and government leaders in acquisition, supervises student MBA projects, and conducts guest lectures and seminars. Before serving at NPS, RADM Greene was an independent consultant focusing on Defense Industry business development strategy and execution (for both the public and private sectors), minimizing lifecycle costs through technology applications, alternative financing arrangements for capital-asset procurement, and "red-teaming" corporate proposals for major government procurements.

RADM Greene served as the Assistant Deputy Chief of Naval Operations (Logistics) in the Pentagon from 1991-1995. As Assistant Deputy, he provided oversight, direction and budget development for worldwide US Navy logistics operations. He facilitated depot maintenance, supply-chain management, base/station management, environmental programs and logistic advice and support to the Chief of Naval Operations. Some of his focuses during this time were leading Navy-wide efforts to digitize all technical data (and, therefore, reduce cycle time) and to develop and implement strategy for procurement of eleven Sealift ships for the rapid deployment forces. He also served as the Senior Military Assistant to the Under Secretary of Defense (Acquisition) from 1987-1990 where he advised and counseled the Under Secretary in directing the DoD procurement process.

From 1984-1987, RADM Greene was the Project Manager for the Aegis project. This was the DoD's largest acquisition project with an annual budget in excess of $5 Billion/year. The project provided oversight and management of research, development, design, production, fleet introduction and full lifecycle support of the entire fleet of Aegis cruisers, destroyers and weapons systems through more than 2500 industry contracts. From 1980-1984, RADM Greene served as Director, Committee Liaison, Office of Legislative Affairs followed by a tour as the Executive Assistant, to the Assistant Secretary of the Navy (Shipbuilding and Logistics). From 1964-1980, RADM Greene served as a Surface Warfare Officer in various duties, culminating in Command-at-Sea. His assignments included numerous wartime deployments to Vietnam as well as the Indian Ocean and the Persian Gulf.

RADM Greene received a BS in Electrical Engineering from Brown University in 1964; he earned an MS in Electrical Engineering and an MS in Business Administration from the Naval Postgraduate School in 1973.

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Discussant: Captain Stephen Huber—Naval Surface Warfare Center, Port Hueneme Division.

Steve Huber was born in West Chester, Pennsylvania. He graduated from the US Naval Academy and was commissioned in 1980, having earned a Bachelor of Science in Oceanography/Physics.

After graduation, Captain Huber served as a Naval Academy Seamanship and Navigation Instructor aboard a 44-ft Luders Yawl, followed by Surface Warfare Officers' School in Coronado, California. He reported to USS STEIN (FF 1065) in 1981, where he served as Gunnery Officer, ASW Officer and Navigator/Administrative Assistant. In October 1983, Captain Huber reported to Naval District Washington, DC, as Aide to the Commandant. Following Department Head School in June 1986, he reported to USS REASONER (FF 1063) as Weapons Officer. He then reported to Destroyer Squadron 5 as Operations Officer in February 1988. In January 1990, he reported to the staff of Commander in Chief, US Atlantic Fleet as the Assistant Surface ASW Officer and Special Operations Officer. From Norfolk he moved to Newport, Rhode Island where he began his studies at the Naval War College in March 1992. In October 1993 he reported aboard USS GARY (FFG 51) as Executive Officer. His following tour was with the staff of Commander, THIRD Fleet, as Flag Secretary. In March 1997 he moved to Washington, DC, where he served as the Combat Systems Training Officer on the staff of the Surface Warfare Division of the Chief of Naval Operations (OPNAV N869T2). He most recently served as Commanding Officer in USS FIFE (DD 991) September 1998 through April 2000. During his Command tour, FIFE deployed to the Eastern Pacific in support of Counter-Narcotics Operations, was the first ship to go through an availability using a private contractor in a public shipyard, and was awarded the SECNAV Energy Conservation Award. At NAVSEA, Captain Huber has served as the Warfare Area Roadmaps Officer in the Surface Ship Technology Directorate (SEA 53) and Deputy Program Manager in PMS 430—the BFTT program office. His last assignment was as Deputy Director, Human Systems Integration Directorate (SEA 03B).

Captain Huber's awards include the Meritorious Service Medal (with two gold stars), the Navy Commendation Medal (with four gold stars), the Navy Achievement Medal, and several unit awards. He holds a Master of Arts Degree in International Studies from Old Dominion University and a Master of Arts Degree in National Security and Strategic Studies from the Naval War College. He was inducted into the International History Honors Society, Phi Alpha Theta, in 1993. He was designated an Acquisition Professional in the January of 1997 and DAWIA Level III certified in Program Management in February of 2002. He was a 2003 National Security Studies Fellow at the Maxwell School, Syracuse University.

A Decision Support Model for Valuing Proposed Improvements in Component Reliability

Presenter: Dr. Keebom Kang joined the Naval Postgraduate School in 1988, where he teaches supply chain, logistics engineering and computer simulation modeling courses for the MBA program. His research interests are in the areas of logistics and simulation modeling in various military applications. He received his Ph.D. in Industrial Engineering from Purdue University. Prior to joining NPS, he was on the faculty of the Industrial Engineering Department at the University of Miami, Coral Gables, Florida (1983-1988). He had held visiting professor positions at Syracuse University (Summer, 1985), Georgia Institute of Technology (Fall, 2003), Asia Institute of Technology in Thailand (Winter, 2004), and Pohang Institute of Science and Technology in Korea (Spring, 2004).

Presenter: Michael Boudreau, Colonel, US Army (Ret), has been a senior lecturer at the Naval Postgraduate School since 1995. While an active duty Army Officer, he was the Project Manager, Family of Medium Tactical Vehicles, 1992-1995. He commanded the Materiel Support Center, Korea, 1989-1991 and the Detroit Arsenal Tank Plant, 1982-1984. COL Boudreau is a graduate of the Industrial College of the Armed Forces; Defense Systems Management College; Army Command and General Staff College; Long Armour-Infantry Course, Royal Armoured Corps Centre, United Kingdom; and Ordnance Officer Basic and Advanced courses. He holds a Bachelor of Mechanical Engineering degree and Master's of Business degree from Santa Clara University, California.

Presenter: Uday Apte, is Visiting Professor of Operations Management, Graduate School of Business and Public Policy, Naval Postgraduate School, Monterey, CA, and Associate Professor, Cox School of Business, Southern Methodist University, Dallas, TX. He teaches operations management courses in the Executive and Full-time MBA programs. His areas of expertise and research interests are in service operations, supply chain management and globalization of information-intensive services.

Prior to joining the Cox School, he worked for over ten years in managing information technology and operations functions in the financial services and utility industries. Since then he has consulted with several major US corporations and international organizations including IBM, Texas Instruments, Nokia, Kinko's, Nationwide Insurance, Nations Bank and The World Bank.

He holds a PhD in Decision Sciences from the Wharton School, University of Pennsylvania, where he taught in the MBA and undergraduate business programs for over ten years. His earlier academic background includes a MBA from the Asian Institute of Management, Manila, Philippines, and Bachelor of Technology from the Indian Institute of Technology, Bombay, India.

Dr. Apte has published over 30 articles, five of which have won awards from professional societies. His research articles have been published in prestigious journals including, *Management Science, Journal of Operations Management, Decision Sciences, IIE Transactions, Interfaces,* and *MIS Quarterly.* He has co-authored one book, *Manufacturing Automation* and has completed work on another co-authored book, *Managing in the Information Economy*.

ABSTRACT: Developing a methodology and a tool for estimating the operational availability (Ao) of a weapon system based on the component-level reliability and maintainability data is the goal of this research. Specifically, we present two spreadsheet models and one discrete-event simulation model using Arena simulation language. The first two models support lifecycle cost calculations and are static in nature. The third model incorporates the interactions among reliability, time to repair and operational availability into a discrete-event simulation model that can support a weapon-system-level risk analysis. These models are developed as proof-of-concept to demonstrate the potential methodology using hypothetical, yet realistic data.

I. INTRODUCTION

The US Department of Defense is engaged in a number of management initiatives (related to weapon system logistics and support) intended to provide reduced lifecycle cost while simultaneously improving operational availability, Ao. Performance-based Logistics (PBL) is one such program that entails the establishment of a particular kind of contractual vendor-client relationship between a logistic-service provider and a weapon-system manager. The Quadrennial Defense Review mandated the DoD implement PBL in order to, "compress the supply chain and improve readiness for major weapons systems and commodities" (OSD, 2001, 56). A key aspect of PBL contracts is their outcome focus; the client organization is supposed to specify key performance goals, and allow the vendor to determine the best way of obtaining those goals (ASN-RDA, 2003).

This paper will not re-examine the core questions of whether PBL works, or why it works, as those questions have been examined extensively elsewhere (e.g., Berkowitz, et al., 2003). Rather, we take as our starting point the question of how best to value the desired outcomes of a PBL contract. After all, as contractual vehicles, the price of the services to be provided must be negotiated. Also, given a limited budget but a proactive program manager, there will always be more opportunities to improve logistical support for a weapon system than dollars available to fund those opportunities.

We assume that opportunities to improve logistics outcomes should be valued on the basis of the cost-effectiveness of those opportunities.[1] As in the private sector, the cost effectiveness of an opportunity (investment) is its mission-value-over-time (profit, in the case of the private sector) divided by its cost-over-time. It would thus be a mistake to take the cost differentials of various logistic service alternatives as a statement of value because cost in no way informs the value of that service to the weapon-system operator. Even if one is willing to assume that current expenditures are cost effective (and hence, any cost reduction would be even more cost effective), there is no way to assess one alternative against another without a direct measure of value; mere cost differentials ignore the fact that the alternatives may have different impacts on mission value.

We will further assume that the mission value of a logistical service is a function of weapon-system performance, as neither a weapon-system component (such as a fuel cell) nor a logistic element (such as spares inventory) can contribute to mission objectives except through the weapon system. From a warfighter's viewpoint, a weapon system is either capable of supporting a mission, or it is not. While a fuel cell may be a necessary condition for the system to be mission capable, it is not a sufficient condition.

Operational availability (Ao) is a primary metric used to determine the probability that a weapon system will be capable of supporting a mission. For example, in an aircraft squadron, Ao of 85% implies that an average of 85% of the aircraft will be available to fly in support of some mission objective. Goals are often stated for Ao levels, and mission planning must take Ao into account. Moreover, neither a war fighter nor a resource manager wanting to make contingency plans should be content with knowing the nominal (target) or the average Ao level.

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[1] Caplice & Sheffi (1994), in reviewing a panoply of logistics metrics, categorized metrics based solely on comparisons of inputs (such as cost comparisons) as *utilization* metrics, while they categorized comparisons of outputs per input (such as what we are calling cost-effectiveness) as *productivity* metrics. They made the point that utilization measures are usually related to process (as opposed to performance) management.

He or she should have a sense of the distribution of Ao around the target levels: the probability that Ao will fall below some critical level.

It is also possible to measure Ao for fuel cells, as well as aircraft; an improvement in Ao for the fuel cell will provide at least some marginal improvement in Ao for the aircraft. But, this improvement will not be one-to-one; large improvements in fuel-cell availability may yield only trivial improvements in aircraft availability, depending not only on the failure rate of the fuel cells, but on the performance and availability of all the other critical components of the aircraft. Likewise, better fuel-cell availability will reduce the risk that a particular weapon system will not be operational for a particular mission, but the magnitude of that risk reduction depends on the probability that all the other critical components of the aircraft are available.

Hence, the value of an improvement of *component* logistics can only be understood in terms of the performance of all the other critical components of a weapon system. Similarly, the value of an improvement in a single logistics element (such as spares inventory) can only be determined in conjunction with other key logistics elements.

The modeling approach we will outline in this paper has applicability beyond PBL. It is useful in understanding the value of component-level logistic services, or services directed at only a subset of logistic elements (inventory only, or depot-level repair only). However, we contend that an implementation of PBL that is fully consistent with the original intent of performance-based service acquisition *must* use an approach similar to the one we outline, because it is impossible to put a value (and, hence, a contract price) on those services without such an approach.

II. LITERATURE REVIEW

While we are arguing for an assessment of value that will provide a more complete picture of the cost effectiveness of a PBL proposal (by providing a numerator to a productivity ratio), we recognize that an estimation of the lifecycle costs of such proposals is far from trivial. Outsourced logistic services for weapon systems are particularly difficult to cost; for example, the ongoing contract management (transaction) costs can be substantial, but are rarely measured (Domberger, Jensen & Stonecash, 2002).

We think such transaction costs are particularly important in light of a recent Government Accountability Office report (GAO, 2004) that was critical of systems-level PBL contracts; this document recommended greater emphasis on PBL contracts at the component level, especially for commodity-type components (which, according to the GAO, reflected “commercial best practices”). PBL contracts on commodities would be especially appealing because vendors providing commodities can expect to enjoy economies of scale that the DoD could not experience (as vendors would be able to offer those commodities across a broad population of users). These increased economies of scale would reduce the price of such services. Unfortunately, of course, aside from domestic transportation and depot-level spares for a relatively small set of components used commonly between defense and industry, the number of critical components (or logistics elements) of weapon systems that can be considered commodities is relatively small. For non-commodity items, a key economic consideration in out-sourcing is the increase in transaction costs entailed by dealing with an outside vendor (Gufstafson, et al., 1996). Such costs increase substantially when one is offering a PBL contract at the component level. As we will show, aside from the additional burden of contract maintenance for many small contracts, the proper valuation and management of such component-level contracts entails the development of a comprehensive model which incorporates key performance dimensions of *all* critical components.

Perhaps in an effort to reduce such transaction costs, or perhaps in response to a complaint that PBL involved too many metrics, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD-ATL, 2004) recently issued guidance for PBL metrics. While clearly indicating that PBL could be applied at the subsystem or major assembly level, the memo listed five key performance criteria: 1) *weapon system* operational availability, 2) *weapon system* operational reliability, 3) *weapon system* cost per usage, 4) logistics footprint for a *weapon system,* and 5) response time required for *weapon system* logistics support.

Of course, these measures are interrelated. We think the central non-cost measure is operational availability. The other three non-cost measures can all be seen in some ways as subsidiary to availability. Reliability (e.g., time to failure), footprint (e.g., number of spares and size of fielded or intermediate maintenance and repair facility) and response time (e.g., time to repair) are all critical determinants of availability. Yet, there may be good reasons to measure reliability, footprint and response time separately. For example, reliability affects not only availability, but also the probability of system failure in the field; likewise, footprint affects not only availability, but operational agility as well. However, operational availability in many ways summarizes reliability, response time and footprint. We will develop a model in the next section that demonstrates the precise interaction between time to failure, time to repair, and spare inventory levels. It also demonstrates how these variables determine availability. Thus, as they affect Ao, footprint, response time, and even reliability are all process and *not* performance measures. We will focus on availability (with the caveat that it may not be the sole determinant of value) because it is necessary to an understanding of value.

In specifying performance outcomes (but not processes) to a vendor, PBL contracts are deliberately designed to transfer some degree of operational and financial risk to a vendor (Doerr, Lewis & Eaton, forthcoming). As risk transfer is an intended outcome of the initiative, and as the risk of falling below a certain level of operational availability is an important performance dimension, it is clearly important to incorporate the risk associated with operational availability at the system level into a measure of value. From the warfighter's point of view, this risk may be the key performance dimension (Eaton, Doerr & Lewis, forthcoming). The warfighter, after all, is less concerned with the average number of mission-capable aircraft than he is concerned with the probability that he will have enough aircraft to fly a particular mission. The procedure we will outline allows the assessment of a proposed logistics improvement not only on the *average* impact that improvement would have on the operational availability of the aircraft, but on the *risk* associated with the operational availability of the aircraft as well.

Weapon systems are, of course, the military's key capital assets related to operational capacity, and the logistics services in question can be seen as primarily affecting the level of operational capacity available to the warfighter. The sort of risk measurement we are proposing is increasingly recognized as central to the valuation of operational capacity of corporate assets in the private sector as well.

Assessments of risk/return profiles for capital assets are, of course, behind the recent work on Real Options (Mun, 200x). And in capacity planning in particular, the incorporation of risk into capacity models was listed in a recent literature review as a key area in which research was expected to develop (Van Miegham, 2003). Risk-based models have recently been applied to the acquisition of production capacity for airfoils used in military aircraft (Prueitt & Park, 2003). Mostly, risk-based capacity models deal with technological, demand, or price uncertainty, and are not directly applicable to the valuation of logistic services and the uncertain impact those services will have on system availability (capacity). The point we are making is that there is growing consensus that a proper valuation of capacity-related planning (such as the planning associated with offering a PBL contract) must include an assessment of risk.

In this paper we develop three models as decision-support systems (Keen & Morton, 1978; Power, 2002; Turban & Aronson 1998). The term “decision-support system” implies use of computer-based systems to:

1. assist the warfighters in their decision process in semi-structured tasks,
2. support, rather than replace, the warfighter’s judgment, and
3. improve the effectiveness of the practical decision-making process.

The dramatic improvements in computer power and software capability (such as spreadsheet and simulation models) allow convenient access to powerful decision-support systems for improved decision making. Making such models available as decision-support systems is the primary goal of this research.

III. MODELS

In this section, we present two spreadsheet models and one discrete-event simulation model using Arena simulation language (Kelton, 2004). The first model primarily supports lifecycle cost calculations but ignores the interactions among reliability, time to repair, and operational availability. The second model, while it does address these basic interactions, does not consider the full range of lifecycle costs. However, both the first and the second model are static—they can only support average case analyses and sensitivity analyses. The third model incorporates the interactions among reliability, time to repair and operational availability into a simulation model that can support a risk analysis, but which does not directly address lifecycle cost issues.

In their current form, these models are intended as a proof-of-concept only. That is, we are not presenting a research case involving field data; rather, we are demonstrating the potential of an approach using hypothetical data.

3.1. Spreadsheet Lifecycle Cost Model (Model 1)

Model 1 is a compressive lifecycle cost analysis model for a hypothetical UAV (unmanned aerial vehicle) case study intended as a proof-of-concept for our modeling approaches. This case study was adapted from Logistics Engineering class lecture notes at the Naval Postgraduate School (Kang, 2004). The complete case study is described in Appendix A, and the spreadsheet model is available from http://web.nps.navy.mil/~mn4310/UAV_Model_1.xls.

This model computes the total system lifecycle cost for major weapon systems from R&D to deployment to phase-out. The lifecycle cost includes research, development, test and evaluation, acquisition, production, operations and maintenance, and phase-out costs. This model is a comprehensive decision-support tool for program managers. The model can be used to establish the baseline total ownership cost of major weapon systems during the planning, as well as operations, stages. The user can conduct sensitivity analyses on various input parameters such as reliability, manning, training, and R&D cost. As the user changes any of the parameters, the model immediately updates the total lifecycle cost, so the user can see the financial impact of input parameter changes in the long run. We suggest the reader download the spreadsheet model and change some of the parameters in the “INPUT” worksheet.

3.2. Revised Spreadsheet Model (Model 2) and Simulation Model (Model 3)

A shortcoming of the spreadsheet model (Model 1) is that it cannot analyze the dynamic relationship between reliability and operational availability. For example, deterioration in reliability of a certain component will decrease the system's operational availability. At the same time, the workload at a repair shop will increase, forcing the repair turnaround time to become longer, which in turn will decrease the operational availability of the system. In Model 1, the average repair turnaround time remains the same regardless of the changes in component reliability.

To overcome this limitation, we have developed a discrete-event simulation model (Model 3) that can be used along with a revised spreadsheet model (Model 2). Model 2 is essentially derived from Model 1. It is a small-scale spreadsheet model to focus on reliability and maintainability. Given logistics input parameters (see Figure 1), Model 2 computes spare-parts requirements, inventory, transportation and repair costs followed by the total maintenance costs over the lifecycle of the system. Model 2 does not consider R&D cost or infrastructure costs. It only considers variable costs while operating the weapon system. Figure 2 shows the total lifecycle maintenance cost of $442,656,976 based on the input parameters in Figure 1. To demonstrate how Model 2 could be used, suppose we improve the MTBF of the main display unit from 1,500 hours to 2,000 hours. The total cost will then be decreased to $440,319,492, representing approximately $2.3 million savings in maintenance cost. This is valuable information for the program manager when s/he makes the component-reliability improvement decisions.

Figure 1. Input Parameter for Model 2

No of Squadrons	4			
No of UAV systems per squadron	10			
No of Air Vehicles per system	4			
No of Ground Control stations per system	2			
Ground Equip Monthly Op Hrs Hours	300	hrs		
AV Flying Hours/Vehicle/month	120	hrs		
AutoLand & Launch/RecMonthly Op Hours	60	hrs		
Repair Turnaround Time	10	days		
Protection Level for Critical Components	0.95			
Protection Level for non-Critical Components	0.85			
Hourly charge for repair including material cost	$500			
Transportation cost per failure	$200			
Annual Inventory rate	21%			
Capital Discount rate	10%			
Lifecycle	20	years		
Ground Control Station Components	MTBF	□	Unit Cost	
Main Display Unit	1000	0.00100	$ 500,000	Critical
Power Supply	4000	0.00025	$ 400,000	Critical
Power Gen	3500	0.00029	$ 300,000	Critical
Air Conditioner	6000	0.00017	$ 400,000	Critical
Guidance & Control	500	0.00200	$ 400,000	NonCritical
Other Ground Equip	MTBF	□	Unit Cost	
Launch & Recovery System	500	0.00200	$ 1,200,000	Critical
AutoLand System	1000	0.00100	$ 2,000,000	NonCritical

Data Terminal	3000	0.00033	$ 1,000,000	NonCritical
AV	MTBF	□	Unit Cost	
Navigation/Avionics	1000	0.00100	$ 200,000	Critical
Engine	500	0.00200	$ 100,000	Critical
Propeller	500	0.00200	$ 50,000	Critical
Video Scanner	2500	0.00040	$ 150,000	NonCritical
IR Scanner	450	0.00222	$ 150,000	NonCritical
IR Data-Link	800	0.00125	$ 200,000	NonCritical

Figure 2. Sample Output of Model 2

Annual Spare Inventory Cost		$ 2,688,000	per squadron
Annual Repair Cost		$ 8,800,857	per squadron
Annual Transportation cost		$ 328,034	per squadron
Total cost per squadron per year		$ 11,816,891	
Total Annual cost		$ 47,267,566	
Total Lifecycle Cost		$442,656,976	

Once the cost analysis is completed (using Model 2), the same input parameters are used for the simulation model (Model 3) to estimate the operational availability and other performance measures of the system (e.g., probability that the operational availability falls below some critical level). Model 2 and Model 3 (simulation model) complement each other.

3.3. Simulation Scenarios

In this simulation model (Model 3), we only consider the critical components (engine, propeller, avionics computer) for a squadron of 10 UAV systems with 40 air vehicles (see Appendix A). When one of these critical components fails, the faulty component is removed from the air vehicle, and an RFI (ready-for-issue) spare is installed. The faulty component is sent to the repair shop to be fixed. After repair, it becomes an RFI spare. When a critical component fails, and an RFI spare is not available, the air vehicle will be grounded (and will become not mission capable, or NMC) until an RFI component is available. A failure of non-critical components may degrade readiness, but the system is assumed to be operable (that is, mission capable or MC).

The input parameters—such as MTBF and number of spares for each component, repair times (in hours), transportation delay (one way, in days)—are read from the spreadsheet (see Figure 3). When a component fails in Scenario 1, it requires 9 days (4.5 days one way) of transportation delay with 10 hours of repair work; this work follows a triangular distribution with a mode of 10 hours, an upper limit of 50% above the mode (i.e., 15 hours) and a lower limit of 50% below the mode (i.e., 5 hours). The waiting time at the repair shop, if any, is estimated inside the simulation. The repair turnaround (TAT) time of 10 hours in Figure 1 for Model 2 approximates the repair TAT of Scenario 1.

Figure 3. Simulation Input Spreadsheet

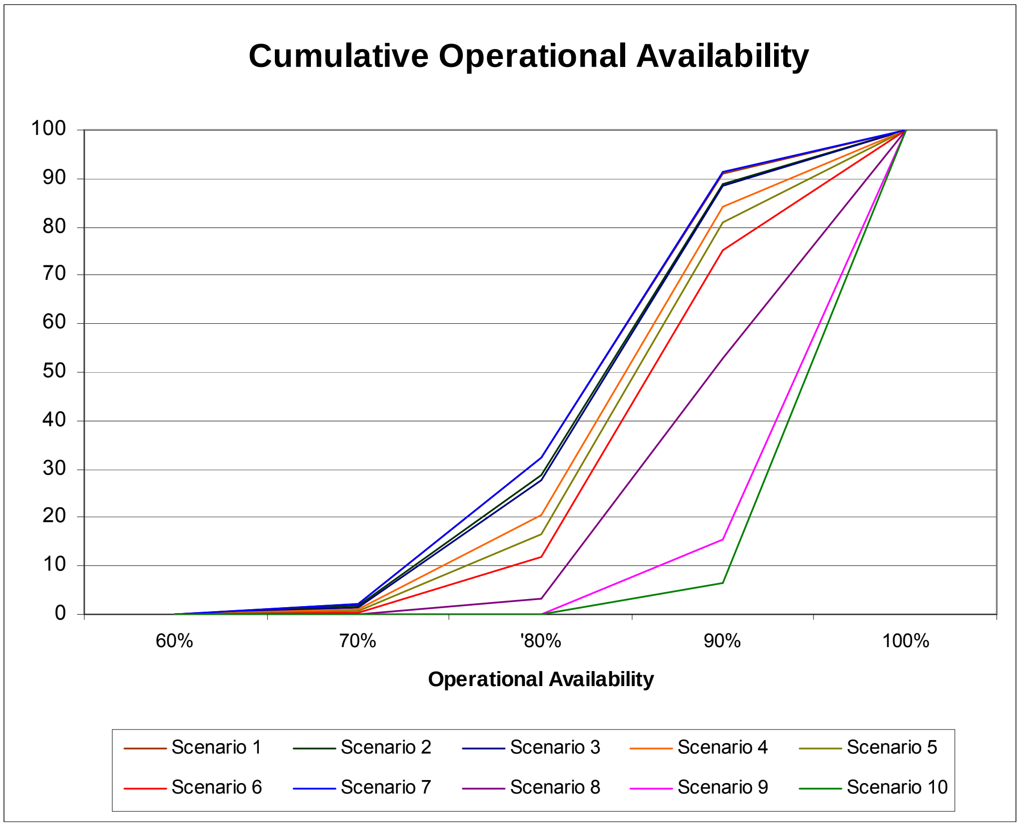
Scenario	MTBF_ Eng	MTBF_ Prop	MTBF_ AvComp	Spare Engines	Spare Props	Spare AvComps	Eng Repair hrs	Prop Repair hrs	AvComp Repair hrs	Trans Delays (Days)
1	1000	500	500	4	6	6	10	10	10	4.5
2	1250	500	500	4	6	6	10	10	10	4.5
3	1500	500	500	4	6	6	10	10	10	4.5
4	1000	750	500	4	6	6	10	10	10	4.5
5	1000	1000	500	4	6	6	10	10	10	4.5
6	1500	1000	500	4	6	6	10	10	10	4.5
7	1000	500	500	10	10	10	10	10	10	4.5
8	1000	500	500	4	6	6	10	10	10	2.25
9	1000	500	500	4	6	6	10	10	10	1
10	1500	1000	500	4	6	6	10	10	10	1

Given the input parameters in Figure 3, Model 3 simulates each scenario over 1,000,000 hours. Multiple scenarios can be executed in one simulation run (e.g., 10 in this case). The results captured for each scenario are the average operational availability (Ao) for the air vehicles in the squadron, along with the cumulative distribution of operational availability. These results are tabulated in Figure 4. The cumulative distribution of operational availability is also depicted graphically in Figure 5.

Figure 4. Simulation Output: Cumulative Operational Availability and the Average Operational Availability for Each Scenario

Cumulative Operational Availability												Avg Op Av
Scenario	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**		
1	0.00	0.00	0.00	0.00	0.00	0.02	2.27	32.25	90.91	100.00		0.837
2	0.00	0.00	0.00	0.00	0.00	0.01	1.68	28.76	88.99	100.00		0.843
3	0.00	0.00	0.00	0.00	0.00	0.01	1.50	27.53	88.47	100.00		0.845
4	0.00	0.00	0.00	0.00	0.00	0.01	0.95	20.50	84.35	100.00		0.857
5	0.00	0.00	0.00	0.00	0.00	0.00	0.55	16.50	80.87	100.00		0.865
6	0.00	0.00	0.00	0.00	0.00	0.00	0.22	11.70	75.25	100.00		0.876
7	0.00	0.00	0.00	0.00	0.00	0.04	2.27	32.43	91.39	100.00		0.837
8	0.00	0.00	0.00	0.00	0.00	0.00	0.03	3.14	52.74	100.00		0.906
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	15.37	100.00		0.948
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	6.63	100.00		0.962

Figure 5. Cumulative Operational Availability



Let's assume that the commander's goal is to maintain an average Ao of 85%. He also knows his mission capability will be critically jeopardized if Ao falls below 80%. Therefore, he wants to estimate the probability that this event might happen, maintaining the average Ao to be above 85%. The results in Figure 4 show that the average Ao of Scenario 1 is 83.7% (the last column of Scenario 1) and the probability of Ao falling to 80% or below is 32.25% (the 9th column with a heading of 80% for Scenario 1). Scenario 1 is not acceptable to the commander since the average Ao is below his goal, and the probability of Ao falling below 80% seems to be too high. He can generate more scenarios (e.g., Scenarios 2 through 10) to assess the impact of changes in component reliability or logistics elements (spare parts, repair and transportation times) on the entire system-level Ao.

In Scenarios 2 and 3, the MTBF of an engine is increased from 1,000 hours to 1,250 and 1,500, respectively. In Scenarios 4 and 5, the MTBF of a propeller is improved from 500 hours to 750 and 1,000, respectively. Improvement in Ao can be observed from the far right-hand side column of the Figure 4. Changes in Scenarios 4 and 5 are preferred to those of Scenarios 2 and 3. In Scenario 6, the MTBFs of both the engine and propeller are increased respectively to 1,500 and 1,000. The overall Ao is increased to 87.6% (from 83.7% of Scenario 1), and the probability of Ao falling below 80% has substantially reduced to 11.7% (from 32.25%). Increase in spare parts (Scenario 7) does not improve the performance at all. However, significant reduction in transportation time (Scenario 8) improves the system performance. In Scenarios 8 and 9, when the transportation delays are reduced from 4.5 days to 2.25 and 1 respectively, Ao jumps to 90.6% and 94.8%, respectively; likewise, the probabilities of Ao falling below 80% drop to 3.14% and 0.08%, respectively. The Scenario 10 is the same as Scenario 9 except that the

MTBFs of an engine and a propeller are increased to 1,500 and 1,000, respectively. Ao hits 96.2% with the probability of Ao falling below 80% now negligible (0.02%).

The parameters in Scenarios 2 through 10 can be input to Model 2 to compute the total maintenance cost for each scenario. For example, by entering the parameters from Scenario 10 into Model 2 in Figure 2, a PM will note results in a total lifecycle maintenance cost of $375,712,781 (i.e., savings of approximately $120 million over the base case of Scenario 1). Scenario 10 provides an Ao 12.5% higher than Scenario 1 (from 83.7% to 96.25%) with the risk of Ao falling below 80% becoming a non-issue.

Models 2 and 3 can potentially serve as a communication tool between the budget community and warfighters. When reliability improvements are made on several components in a complex system, the warfighter's primary concern is readiness, or Ao, while the budget analysts' focus is on financial implications. These two models provide valuable solutions to both communities.

IV. SUMMARY

Providing reduced lifecycle cost and, at the same time, improving operational availability are fundamental goals of the Performance-based Logistics (PBL) and other logistics initiatives of the U.S. Department of Defense. In many PBL contracts, the contractual arrangements are typically stipulated at the level of individual components (such as a fuel cell) or a logistic element (such as inventory of certain spare parts). While achieving component-level performance goals is certainly important, what really matters to a warfighter is the operational availability of the weapon system. Hence, there is a need to develop a methodology and an apparatus for estimating the operational availability (Ao) of a weapon system based on the component-level reliability and maintainability data. This current research is aimed at this need.

Specifically, we present two spreadsheet models and one discrete-event simulation model using Arena simulation language. The first model primarily supports lifecycle cost calculations, but ignores the interactions among reliability, time to repair, and operational availability. The second model, while it does address these basic interactions, does not consider the full range of lifecycle costs. However, both the first and the second model are static—they can only support average case analyses and sensitivity analyses. The third model incorporates the interactions among reliability, time to repair and operational availability into a simulation model that can support a weapon-system-level risk analysis. In their current form, these models are developed as a proof-of-concept. That is, we are not presenting a research case involving field data, but rather are demonstrating the potential methodology and a tool using hypothetical, yet realistic, data.

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APPENDIX A:

Unmanned Aerial Vehicle (UAV) Case Study

A UAV system consists of four air vehicles (AV's), two ground-control stations (GCSs), modular mission payloads (MMPs), data links, remote data terminals (RDTs) and an automatic landing system. A total of 8 squadrons (two squadrons in each coast of CONUS, and one each for Pacific, Indian, Mediterranean, and Atlantic Oceans) will be established to accommodate the new system. Each squadron will have its own intermediate-level maintenance capabilities. Each squadron will have 10 VTUAV systems. Detachment personnel (for each UAV system) will consist of three officers (one OIC and two mission officers), three Chief Petty Officers (CPOs) and 12 enlisted. I-Level Maintenance personnel will consist of one officer, one Chief petty officer and ten enlisted. Squadron headquarters personnel will be made up of seven officers, ten CPOs and twenty enlisted. Composite costs for personnel are estimated as follows: Officer—$140,000 per year, CPO—$115,000 per year, Enlisted—$70,000 per year.

Production begins in Fiscal Year 2004, with all VTUAV's scheduled for field tesing in the year following their production. A total of 80 VTUAV systems will be produced; the life-cycle of the program is estimated to be 30 years (2005-2034). The risk of loss of an AV in peace time is 2-7% per year, while the risk of loss of an AV in operation during a contingency is 15-30% per year. A chance of a contingency during the life-cycle of the program is 15% per year. Lost AVs will be replaced the next year. However, no orders for replacement AVs will be placed last 5 years of the life-cycle (i.e., YR 2025 – 2029). We are assuming by then new UAV systems will gradually replace the current ones.

Research and development costs are $15 million for FY 01, $20 million in FY 02 and $50 million in FYs 03 and 04. The marginal production cost of AV (with payload) is $1 million. The cost of maintaining a production capability throughout the life of the system is $12 M per year for every year any aerial vehicles are produced. Thus, the annual production cost of AV is $12M + $1M * (# of AV produced). Ground-Control Equipment, which consists of two GCSs, RDTs, test equipment and an automatic landing system, will cost $20 million per system. The I-level operating cost is $6 million/yr per I-level plus an additional one-time capital investment of $25 million (including installation of test equipment) prior to the year of operation. A capital discount rate of 10%/yr the inflation rate of 4%/yr will be used.

Billet requirements are based on all personnel fully qualified/current/certified to perform all missions/Navy Enlisted Classification Code (NEC)/Military Occupational Specialty (MOS). Operators are required to have functional applications of the use and control of the UAV, and will be trained in operation of all aspects of the UAV navigation, launch flight control and recovery. Officers and CPOs will attend additional training on preflight planning, mission profile construction and UAV tactical-intelligence integration. Costs for the training will be $1,600/person/week for the basic training and $3,000/ person/week for the advanced training.

An attrition rate of 25% per year is used after the first year, including personnel rotation. Required training is as follows:

Detachment personnel

Basic UAV Training (Officers, CPOs, junior enlisted): 10 weeks
Advance Training (Officers and CPOs only): 5 weeks

I-Level Maintenance personnel

Basic Maintenance Training (Officers, CPOs, junior enlisted): 20 weeks
Advance Maintenance Training (Officers and CPOs only): 5 weeks

Squadron Headquarters personnel

Basic UAV intelligence course (Officers, CPOs, junior enlisted): 10 weeks
Advance Training (Officers and CPOs only): 5 weeks

Spare parts management will be consolidated at the I-Level on a one-for-one exchange. We will assume that the transportation cost is $100 per shipment (i.e., $ 200 per failure). Spares replacement and repair materials cost will be equal to 50% of the value of spares per year. Sparing levels will be as follows: critical units—95% and non-critical units— 85%. Maintenance turnaround time (TAT), including transportation delays, for I-Level is 10 days and D-Level is 40 days. It is assumed that 80% of failures can be repaired at the I-Level (thus 20% at the D-level). Spare-level calculations are based on "t =10 (0.8) + 40 (0.2) = 16 days." D-Level cost is estimated to be $5,000 per repair including the transportation costs. Ground equipment is expected to operate 300 hours per month; the AV flying hour is estimated at 120 hours per month per vehicle. The launch/recovery and the auto-landing systems are used 20% of the time the ground-control station is in operation (i.e., 60 hours per month). POL (petroleum, oil and lubricant) costs are estimated at $60 per flight hour. The MTBF of each component, its cost, and the required protection level (customer service level) are included as follows:

	MTBF	Cost	Criticality
I. Ground Station (2 per VTUAV system)			
Main Display Unit	1,500 hrs	$ 500,000	critical
Power Supply	4,000 hrs	$ 400,000	critical
Power Generator	3,500 hrs	$ 300,000	critical
Air Conditioner	6,000 hrs	$ 400,000	critical
Guidance & Control	500 hrs	$ 400,000	non-critical
II. Other Ground Equipment (1 per VTUAV system)			
Launch/Recovery System	500 hrs	$1,200,000	critical
Auto-landing System	1,000 hrs	$2,000,000	non-critical
Data Terminal	3,000 hrs	$1,000,000	non-critical

III. AV and Payload

Engine	500 hrs	$ 100,000	critical
Propeller	500 hrs	$ 50,000	critical
Navigation/avionics	1,000 hrs	$ 200,000	critical
Video Scanner	2,500 hrs	$ 150,000	non-critical
IR Scanner	450 hrs	$ 150,000	non-critical
IR Data-Link	800 hrs	$ 200,000	non-critical

The System activation/deactivation plan is as follows:

System Activation plan:	FY 2005 - 20 systems
(2 squadrons at a time)	FY 2006 - 20 systems
	FY 2007 - 20 systems
	FY 2008 - 20 systems
System Deactivation:	FY 2031 - 20 systems
(phase-out) plan	FY 2032 - 20 systems
(2 squadrons at a time)	FY 2033 - 20 systems
	FY 2034 – 20 systems

Understanding the Impact of Mandated RFID Compliance on the DoD Supply Base

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Presenter: Mark A. Barratt, has over ten years experience in service operations and has been lecturing on logistics and supply-chain management for the last ten years at both undergraduate and postgraduate levels. He has extensive business experience encompassing law and supply-chain management. He received his PhD in Supply-Chain Management from Cranfield School of Management, Cranfield Univeristy. His PhD research focused on supply-chain relationships and information exchange and won an Economic and Sociological Research Council (ESRC) doctoral dissertation award. His research has been published in a number of leading journals. He is currently exploring how organizations develop and extend collaboration through information sharing across the supply chain. He is also interested in visibility in the supply chain, collaborative cultures, and the use of RFID in supply chains.

ABSTRACT

In response to the Department of Defense's (DoD) mandate that all of its suppliers should adopt Radio Frequency Identification Devices (RFID), this research seeks to understand the impact of the mandate on the DoD supply-base. Specifically, the goals of the research are to understand: (1) the compliance strategies for RFID in defense supply chains with mandated compliance, (2) the adoption factors, timeframes, and costs of such RFID implementation, and (3) the impact on purchasing, logistics, supply-chain continuity, and supply-chain relationships. To achieve these goals, two stages of data collection are currently underway: (1) several case studies are being developed and (2) an industry-based survey is being developed. In support of the case studies, multiple interviews are being conducted together with detailed process mapping. This approach facilitates the identification of enablers, timeframes, barriers, benefits, costs, impacts, organization, best practices, projects, etc. The industry survey will provide the opportunity to test the conclusions and findings from the case studies as well as to identify industry trends and directions. Currently, the early indications of the research reveal that, although DoD suppliers have developed an initial "slap and ship" capability, they are still some distance from having a robust enough capability to meet compliance for significant volumes of product order. Their development of a longer-term sustainable capability is being hampered by the immaturity of available technology and the lack of clarity in the detailed requirements from the DoD.

Logistics Transformation through Sense-and-Respond Logistics Network

Presenter: The Honorable Jacques S. Gansler, former Under Secretary of Defense for Acquisition, Technology, and Logistics, is the University of Maryland's Vice President for Research and the Roger C. Lipitz Chair in Public Policy and Private Enterprise. As the third-ranking civilian at the Pentagon from 1997 to 2001, Professor Gansler was responsible for all research and development, acquisition reform, logistics, advance technology, environmental security, defense industry, and numerous other security programs. Before joining the Clinton Administration, Dr. Gansler held a variety of positions in government and the private sector, including Deputy Assistant Secretary of Defense (Materiel Acquisition), assistant director of defense research and engineering (electronics), executive vice president at TASC, vice president of ITT, and engineering and management positions with Singer and Raytheon Corporations. Throughout his career, Dr. Gansler has written, published, and taught on subjects related to his work. He is a Member of the National Academy of Engineering and a Fellow of the National Academy of Public Administration. Additionally, he is the Glenn L. Martin Institute Fellow of Engineering at the A. James Clarke School of Engineering, an Affiliate Faculty member at the Robert H. Smith School of Business and a Senior Fellow at the James MacGregor Burns Academy of Leadership (all three at the University of Maryland). During 2003–2004, he served as Interim Dean of the School of Public Policy at that institution.

Presenter: Kenneth A. Gabriel, is Senior Research Scholar and Program Manager at the Center for Public Policy and Private Enterprise, School of Public Policy, University of Maryland, where he leads research and pilot demonstration of focused and efficient logistics. He is also Professor of Strategy and New Venture Creation at the RH Smith School of Business, University of Maryland. Prior to assuming his position at the University of Maryland, Dr. Gabriel served as Founder, President and CEO of High Performance Materials Group, Inc., Boothwyn, PA. He also founded and led InterConcepts, Inc., a consulting and business incubator firm in Alexandria, VA. Dr. Gabriel served in key technology leadership roles in the Department of Defense including serving as Director, US Army Research Office in Washington, DC and Director of Research, US Army, Pentagon, Washington, DC. Dr. Gabriel holds a PhD in Physical Chemistry and two MS degrees in Chemistry and Chemical Engineering from University of Illinois, Chicago. He also earned a MA in National Security from Georgetown University School of Foreign Service, Washington, DC.

Commercial and military logistics continue to evolve from amassing supplies, through supply chain management, to (more recently) sense-and-respond networks. The realization that "demand-pull" is inherently more efficient than a "supply-push" strategy propels the migration from supply chains to demand networks. Major commercial enterprises in the United States and abroad have already transformed their supply chains to include Sense-and-Respond Logistics (SRL) elements. Likewise, military planners and leaders have recently recognized the need to adopt SRL to transform military logistics to significantly enhance military readiness while reducing costs.

Military supply-chain modernization has recently been the subject of increasing interest as a result of publicized logistics challenges in Iraq and other fronts in the global war on terror. In response to the need for highly maneuverable, flexible, decentralized logistics, planners have sought to transform military logistics from "legacy" government-provided logistics support to Contractor Logistics Support (CLS). This, in turn, has brought about the need to retain multiple support strategies to satisfy both complex supply-chain issues and, as may be expected, the need to overcome much institutional resistance to this logistics transformation.

This paper presents the successful migration of logistics support of a modern weapon system from a traditional "legacy" approach to an efficient supply-chain management portal that begins to incorporate a SRL strategy. The demonstrated web-based portal was the first of its kind to integrate Government logistics assets with CLS assets in real time. This study will review ongoing research and demonstration pilot projects to further migrate logistics from the supply-chain portal to sense-and-respond logistics (or Demand Network Logistics) through intelligent agents, fused sense-and-respond functionalities, Automatic Identification Technology (AIT) and Radio Frequency Identification (RFID).

Obstacles to logistics transformation within and between the nodes of the supply-chain network—as well as network security and availability—will be discussed along with prescriptions to overcome these hurdles. Strategies to implement these technologies within the military services—and ultimately across coalition forces—will be presented.

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